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WORLD MARITIME UNIVERSITY

Malmö, Sweden

**EFFICIENCY AND COMPETITIVENESS
ANALYSIS OF PORT OF İZMİR**

By

OĞUZ ALPCAN

Turkey

A dissertation submitted to the World Maritime University in partial
fulfilment of the requirement for the award of the degree of

MASTER OF SCIENCE

In

MARITIME AFFAIRS

(SHIPPING MANAGEMENT AND LOGISTICS)

2019

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.



(Signature) :

(Date) : **22/09/2019**

Supervised by: **Professor Shuo MA** (說嘛)

World Maritime University

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In the name of Allah, the Most Beneficent, the Most Merciful. All the praises and thanks be to Allah, the Lord of all that exists. I thank Allah for granting me to study at World Maritime University (WMU). Without Allah's allowance nothing can happen, if Allah wills, no one can stop to happen.

I thank the founder of the modern Republic of Turkey Mustafa Kemal Atatürk, his fellow fighters, and all the martyrs for their holy effort to provide an independent, democratic country to me and my people. I thank all my dearest family members and my beloved one for their support and motivation during my study in Sweden.

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WMU is a so special and unique place. During my study here, I have had sisters and brothers from almost all around the world. In cold and dark Scandinavian days, WMU fellowship was pure warmth and joyful. I thank my dear friends for their collaboration every part of our life in WMU.

Mrs. Lyndell Lundahl, beginning from my first day at WMU I noticed your extraordinary care for us. I appreciate your diligence.

I am proud of attending this lovely university and being a part of it.

ABSTRACT

Title of Dissertation : **Efficiency and Competitiveness Analysis of Port of İzmir**

Degree : **Master of Science**

Port of İzmir (POI) was a very important public container terminal in Turkey's foreign trade for many years. The port was setting throughput records until the 2009s and it was the only terminal serving at the Aegean shores of Turkey. Nevertheless, in recent years, while its throughput has decreased more than 30%, the new private competitors developed their business in a rapid movement. Their total throughput has already overcome the POI.

Turkish Government has a big scaled dredging and construction investment plan for POI. On the other hand, there is another heavy going hub container terminal construction in the region that is called Çandarlı Port which has a 4 million TEU capacity while the POI project is limited by 2.5 million TEU.

In this study, quantitative methods are implemented to measure the current efficiency of POI among 17 container terminals from East Mediterranean Sea at national or international level which includes its main competitors in the region and also to carry out the investment appraisal of two-port projects. Data envelopment analysis was used for technical efficiency measurement of POI. Capital budgeting techniques; net present value (NPV), internal rate of return (IRR), payback period (PP) is used for cost-benefit analysis of the two projects in the business profitability perspective. The probabilities of different input-output combinations of cash flows (CFs) were examined with the Monte Carlo Simulation method. Regression and trendline analysis was also used for determining the significant variables for the demand forecast. Finally, findings and recommendations about the topic were presented as a conclusion.

The aim of the study is to provide an analytical contribution to the decision-makers.

KEYWORDS: Capital Budgeting, Container terminal, DEA, Deviation, Dredging, Efficiency, Hub port, Investment appraisal, IRR, Monte Carlo Simulation, NPV, Payback Period, Port investment.

Table of Contents

DECLARATION	ii
ACKNOWLEDGEMENTS.....	iii
ABSTRACT.....	iv
List of Figures	viii
List of Tables	x
List of Abbreviations	xi
CHAPTER ONE - INTRODUCTION TO STUDY	1
1.1. Importance of the Study.....	4
1.2. The Objective of the Study	7
1.3. Order of Presentation	7
1.4. Scope and Methodology.....	8
CHAPTER TWO - INTRODUCTION TO PORT OF İZMİR.....	9
2.1. Overview.....	9
2.2. Competitors.....	17
2.3. Hinterland	19
2.4. Rehabilitation Project of İzmir Bay and Port (Great Gulf Project)	26
2.5. Background and the Statement of the Problem	29
2.6. Research Questions and Hypotheses	34
CHAPTER THREE – LITERATURE VIEW AND METHODOLOGY	35
3.1. Port Productivity and Efficiency.....	35
3.2. Data Envelopment Analysis (DEA).....	38

3.3. Port Investment and Finance.....	41
3.4. Cost-Benefit Analysis (CBA)	44
3.4.1. Payback Period	45
3.4.2. Net Present Value	46
3.4.3. Internal Rate of Return	48
3.5. Previous Studies.....	51
CHAPTER FOUR – IMPLICATION OF METHODOLOGY AND FINDINGS	52
4.1. Efficiency Analysis.....	52
4.1.1. Selection of Input and Output Variables.....	52
4.1.1.1. Berth Length	53
4.1.1.2. Depth at Berth.....	54
4.1.1.3. Number of Quay Cranes	55
4.1.1.4. Container Stockyard Area.....	56
4.1.1.5. Annual Container Throughput	56
4.1.2. Selection of DMUs	56
4.1.3. Data Issues	57
4.1.4. Findings	59
4.2. Investment Appraisal of İzmir Bay and Port Rehabilitation Project	62
4.2.1. Direct Investment Cost Prognosis.....	62
4.2.2. Demand.....	64
4.2.3. Future Container Freight Demand	68
4.2.3.1. Micro Projection	68
4.2.3.2. Estimation of Transshipment Cargo.....	74

4.2.4. Cost-Benefit Analysis (CBA) with Monte Carlo Simulation	79
4.2.4.1. Assumptions.....	80
4.2.4.2. Findings	82
CHAPTER FIVE – CONCLUSION AND RECOMMENDATIONS	87
5.1. Limitations and Criticism of Study.....	87
5.2. Conclusion	88
5.3. Recommendations.....	91
REFERENCES	93

List of Figures

Figure 1. World seaborne trade.....	3
Figure 2. World seaborne container trade.....	3
Figure 3. Port of İzmir	10
Figure 4. POI's yearly container throughput	11
Figure 5. POI cargo volume in tonnes	12
Figure 6. Yearly Cruiser Vessel Numbers at POI.....	13
Figure 7. Layout Plan of POI.....	14
Figure 8. Nemrut Bay Container Terminals	17
Figure 9. Total container throughput of POI's three competitor ports	18
Figure 10. Railway and Highway Connections	20
Figure 11. Export and import in the Aegean Region of Turkey	21
Figure 12. Population changes in Aegean Region.....	22
Figure 13. City populations of Aegean Region	23
Figure 14. City population changes	23
Figure 15. Agricultural production in value	24
Figure 16. Agricultural production in volume	25
Figure 17. Aegean Region GDP growth.....	26
Figure 18. Rehabilitation Project of İzmir Bay and Port	27
Figure 19. POI layout plan after rehabilitation project.....	28
Figure 20. Container vessel size growths	30
Figure 21. Heavy traffic at POI side road.....	31
Figure 22. Çandarlı Port breakwater.....	33
Figure 23. NPV comparison for project L&S.....	50
Figure 24. Maersk S-Class vessel in the shipyard and in-service.....	54
Figure 25. World and Turkey Container Transport	64
Figure 26. Aegean Region and Turkey Annual Throughputs.....	65
Figure 27. Migration to İzmir	67

Figure 28. GDP Change of İzmir.....	67
Figure 29. Normality test histogram.....	70
Figure 30. Turkey’s foreign trade forecast until 2050	71
Figure 31. Total container throughput with regression.....	72
Figure 32. Aegean Region container throughput forecast by trendline analysis	73
Figure 33. Main container shipping routes	75
Figure 34. Seaborne Container trade growth rates	78
Figure 35. Transshipment cargo forecast	78
Figure 36. POI project simulation NPV distribution	84
Figure 37. Çandarlı project simulation NPV distribution.....	84
Figure 38. POI project simulation IRR distribution	85
Figure 39. Çandarlı Project Simulation IRR Distribution	86
Figure 40. Highway construction to Çandarlı Port.....	90

List of Tables

Table 1. POI Berth Specifications	14
Table 2. POI Profit Loss Table	16
Table 3. Container Terminal Technical Data of POI's Competitors	19
Table 4. Project L&S Data Table.....	49
Table 5. Input and Output Data of DMUs	57
Table 6. Descriptive Statistics of Variables.....	58
Table 7. Correlation of Variables	58
Table 8. Results of DEA	59
Table 9. Summary of Output Targets	60
Table 10. Main Hinterland Population Changes.....	66
Table 11. Unit Root Tests	68
Table 12. Descriptive Statistics of Variables.....	69
Table 13. Correlation of Variables	69
Table 14. Final Equation.....	70
Table 15. Deviation Distances and Durations	75
Table 16. Time and Distance Advantages for Feeding Routes After Transshipment.....	76
Table 17. Descriptive Statistics	83

List of Abbreviations

ARMA	Autoregressive Moving Average
BCC	Banker, Charnes, Cooper
BOT	Build-Operate-Transfer
CBA	Cost-Benefit Analysis
CCR	Charnes, Cooper, Rhodes
CF	Cash Flow
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DCF	Discounted Cash Flow
DMU	Decision-Making Unit
GDP	Gross Domestic Product
IMF	International Monetary Fund
IRR	Internal Rate of Return
ITF	International Transport Forum
ITTS	Institute of Trade and Transportation Studies
İZSU	İzmir Water and Sewerage Administration
İZTO	İzmir Chamber of Commerce
MHC	Mobile Harbour Cranes
NPV	Net Present Value
POI	Port of İzmir
PP	Payback Period
RTG	Rubber Tyre Gantry
STS	Ship-to-Shore / Shore-to-Ship
TCDD	Turkish State Railway Company
TEU	Twenty-Foot Equivalent Unit

TurkStat	Turkish Statistical Institute
UAB	Ulaştırma ve Altyapı Bakanlığı (Ministry of Transport and Infrastructure)
UNCTAD	United Nations Conference on Trade and Development
USACE	US Army Corps of Engineers
WSC	World Shipping Council

CHAPTER ONE - INTRODUCTION TO STUDY

By the industrial revolution, development of the steam engine and then the internal combustion engines wiped out the dependency of vessels to the mercy of wind and currents. (Brooks, M. R., 2000) Hence, seaborne trade had made big moves from that day to this. During this progressive motion, some stagnancy intervals occurred in linked with world politics and economics. Today, the world seaborne trade is keeping its increasing trend after the 2009 stagnation period which was caused by 2008 financial crises. United Nations Conference on Trade and Development (UNCTAD) Review of Maritime Transport report (2018) states that the total world seaborne trade reached 10.7 billion tons in 2017 and the annual growth of seaborne trade was approximately 4% in the same year which was the fastest in last five years. According to the Clarkson Research (2019) database, the sum amount was 11.9 billion tons in the following year, in 2018. Nowadays, it is generally accepted approximately 90% of volume and 70% of value for international trade is carried by ships. (Ma, 2018)

Seaports are the beginning and ending place of maritime adventure and they interconnect the land to the sea and vice versa. The maritime shipping industry is part of a big network that consists of all the services for the cargoes which are transported from supply points to the demand points. This complex network does not contain just solely means of carriage of goods at sea but also includes different types of services like consolidation, handling, storage, clearance, and inland transportation. Therefore, seaports where many of the

aforementioned different services related to cargoes are presented, are the main key nodes of the big supply chain network. Such that, they can create their own demand or the transportation demand can create the ports.

Containerization was the beginning of a new era in maritime shipping industry in 1956. The first vessel which carried that steel boxes “Ideal X” was loaded only 56 containers at his voyage from Newark to Port of Houston. However, today ultra-large vessels can carry more than 20K Twenty-foot equivalent unit (TEU). Ideal X was not a container vessel but in the same a year “Maxton” a tanker was converted to a container vessel. The main idea behind the containerization was speeding up the loading and discharging of the shipping cargo. Hence, the seaports could not remain unresponsive to the development of containerization. In terms of general cargo, handling evolved. Vessels were not staying at berth for weeks anymore. Loading or discharging was completing even in hours. The need for workforce at ports was decreasing but the cranes and equipment were gaining importance. According to the UNCTAD report (2018) nowadays, there are 873 container handling port and World Shipping Council (WSC) (2019) states an average of 9,000 port calls are made by container vessels weekly all around the world.

The container shipping industry is developing faster than the general seaborne trade because of the shift of cargoes from tramp side to liner side of shipping industry; thus shifting from bulk, pallets, barrels, bales, bags, any other packages to the steel boxes, in summary, the containerization. Clarkson Research (2019) data shows that; the world annual average seaborne trade increase was 3.75% by 1996. But the increase of world annual average seaborne container trade was 6.97% in the same period. (In Figure 1 and Figure 2) It was an almost double increase in container shipping. Nowadays, some countries which are at a strategic intersection point of main sea routes are investing in transshipment hub container terminals to utilize this advantage and provide a contribution to their economies. For instance, the small island country Singapore is obtaining approximately 7% of its gross domestic product (GDP) from maritime related industries.

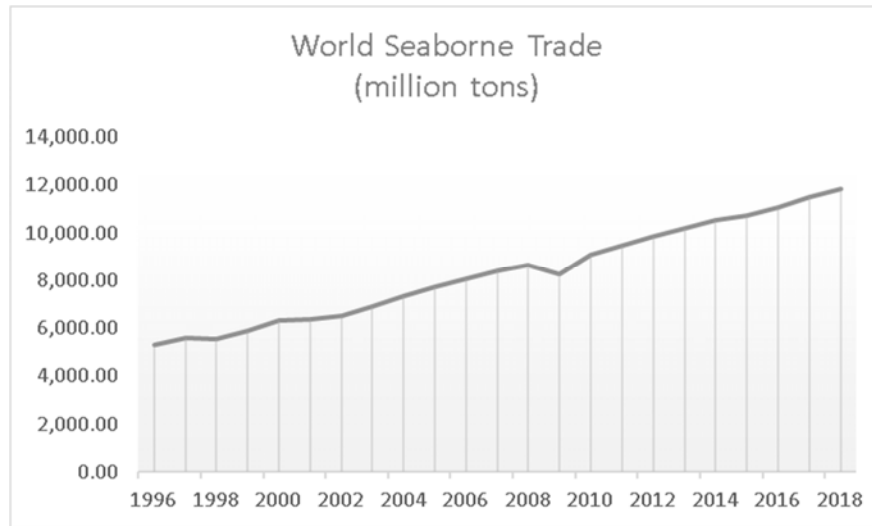


Figure 1. World seaborne trade
(compiled from Clarkson data)

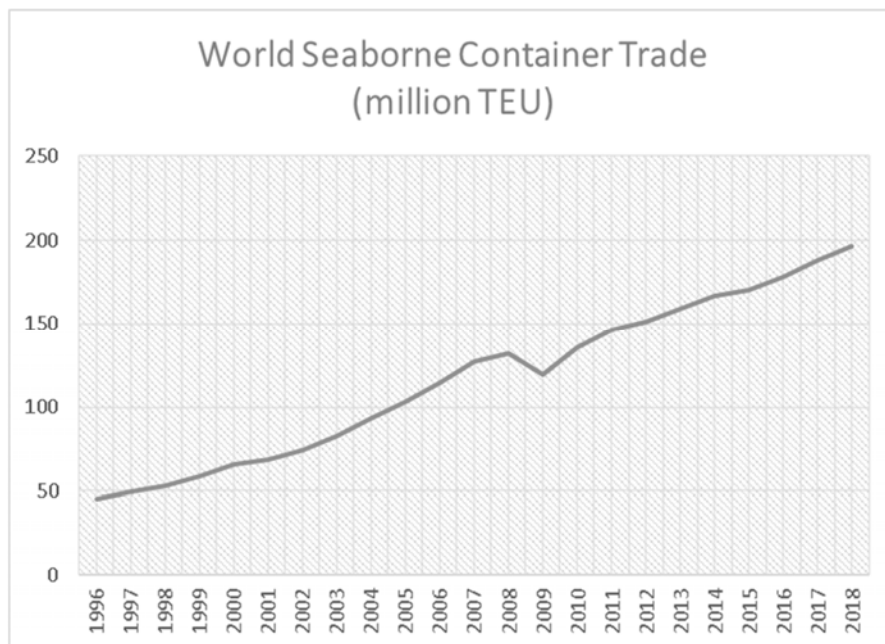


Figure 2. World seaborne container trade
(compiled from Clarkson data)

According to the Clarkson Research data; in 2018, 1.9 billion tons of cargo was containerized and this was the %16 of the total seaborne trade volume. However, in terms of value 75% world seaborne trade is composed of general cargo which mainly carried by container shipping. (Ma, 2018). Hence, the container shipping industry has a big importance in today's international trade and the container terminals are especially vital for maritime transport dependent countries.

Turkey is a peninsular country which is covered by the Black Sea and the Mediterranean Sea. Besides, it has the two very important passageways Bosphorus and Dardanelles Straits which were the capital of trade and culture in several periods of world history. Nevertheless, according to the International Monetary Fund (IMF) statistics, modern Republic of Turkey is the 18th biggest economy in the world with a 960 billion USD GDP and Port of İzmir (POI) is one of the big port and container terminals in Turkey.

In this context, this study will focus on container terminal of POI that also contains facilities for different types of cargoes like bulk, general cargoes, passengers and cars but container services are mainline of business. And, the first two dock cranes were installed to POI in 1986.

This chapter of the study contains four subheadings which are explaining the importance and objectives of the study, giving the order of presentation and interpreting the scope of research respectively. Nevertheless, the quantitative analyse methods of study will be addressed under the last subheading related to scope and methodology.

1.1. Importance of the Study

In 2004, more than 90% export and import of Turkish Aegean region were carried out by POI. Besides, 27% of total public ports' cargo handling amount was realized at POI and it had the highest container handling port in Turkey in the same year. (İzmir Chamber of

Commerce [İZTO], 2004) In 2004, POI reached the 848,000 TEU annual container throughput.

Today, container handling amount is decreasing at POI gradually. Annual container handling was approximately 610 thousand TEU in 2018 and it was lower than the numbers in ten years ago. (Ministry of Transport and Infrastructure [UAB], 2019) After 2008 global financial crises all the container terminals were affected negatively in Turkey and whole around the world but even though the brilliant previous years of 2008 times could not be obtained the recovery started in 2010 and the container throughput of seaports began to grow.

The downfall of business in POI has different causes. The most important factors are the new private operated container terminals which have higher draft capacities and they are away from the city's traffic congestion in the Nemrut Bay that locates approximately 50km north side of İzmir. Approach channel and berth depths of POI cannot correspond to bigger vessels' entrance to the port. Hence, the cargoes were transhipped to the feeder vessels in close hub ports (for instances Piraeus) in past years and the costs were increasing for liner companies and for the shippers. Besides, because of the population increase and insufficient urban infrastructure, there is huge traffic congestion in İzmir. Nevertheless, the POI is locating at the centre of the city.

In 1999, to solve the draft problem of POI, High Planning Council of Turkey had performed two bids for dredging and construction of new terminals by land reclamation. (Baran, 2006) But, both of them were cancelled by the court because of the expansion plans were not fulfilled.

After the year of 2002, the new government of Turkey adopted a policy of privatization for public ports. Since then, many public-owned ports have been leased to private companies for long terms with expansion and investment concessions. Also, POI was subject to privatization but initial attempts were cancelled by the court. Then, in 2007 a

consortium won the bid by 1,275 million USD but after the 2008 financial crises, they withdrew by forfeiting 15 million USD deposit. Now only POI and Haydarpaşa Port are the two public container terminals which have different problematics.

Nowadays, a new heavy going project which is called İzmir Gulf and Port Rehabilitation Project has been prepared by İzmir Municipality and Turkish State Railway Company (TCDD). City management is responsible for north circulation channel dredging, TCDD is responsible for south approach channel and port area dredging and infrastructure, superstructure investments. North channel is aiming to increase the water circulation in the gulf for ecological reasons. Hence, it is more environmental based. Nevertheless, south approach channel dredging is just for serving to the vessel traffic. Dredging and port investment project were priced 800 million TRY at environment impact assessment report. (Dokay Ltd, 2016) However, there is no detailed distribution of project costs and this amount is away from reality. 300 million USD is mostly mentioned in the press but there are no public detailed calculations about it. Nevertheless, in a İzmir Development Agency report, it is stated that 650 million USD investment required for expansion of POI container and passenger terminals. (İzmir Development Agency, n.d.)

Another issue is the mud discharge during the dredging. City municipality has bid a project preparation consultancy service to use the material obtained from dredging and the project will be prepared by October of 2019. However, mud discharge proposals are in contradiction with the environmentalism of the ecological aimed water circulation channel. All the suggestions are in the direction of discharging the material to some areas which are bordering on a natural conservation bird sanctuary wetland. Hence, there is an opposite public opinion about some of the mud discharge proposals.

On the other hand, Gulf of İzmir has sediment input matter for long years in the past. If the small ones are included, there are 33 streams in total to the gulf. (Torlak, 2015) Hence, the gulf has been under threat of deposit since the 19th century. In 1886, Gediz riverbed

was moved to the northern part of the gulf because of the alluvial deposit that filled and converted 6 km long seabed to land. (Kaboğlu et al., 2016)

Finally, POI dredging, land reclamation, and construction details included investment budget is unclear. Whereas, the 300 million USD assumption is considered as reflecting the reality it will be a big amount to finance. Furthermore, dredging will solve the draft problem in the short term. Eventually, the chronic sediment input will cause new dredging necessities in the gulf. Moreover, the discharge of dredging material is another environmental problem and it can create extra cost in case of different practices.

In conclusion, this study seeks an assessment of a current issue that consists of huge investment, interventions to the natural habitat and expectation of profit in return and this issue is still at the beginning phase of the project. Hence, the study may provide a contribution to the decision-makers.

1.2. The Objective of the Study

Firstly, the current efficiency of the POI container terminal will be compared with other selected container terminals and the obstacles of the rehabilitation project will be discussed. Then an investment appraisal of the proposed alternative project, which is the Çandarlı Port investment will be presented.

1.3. Order of Presentation

The study is comprised of five chapters. The first one specifies the importance and objective of research and it is an introduction for the study. Chapter two contains brief information about POI, its competitors and socio-economic factors of their hinterland. Besides, the problem and the research questions are stated in the second chapter. Chapter three is about the methodology which will be implied to the analysis and the previous studies which used a similar methodology. The efficiency analysis and investment

appraisal realized in chapter four. The findings are presented in the same chapter. Finally, chapter five is about the criticism of the study and conclusion with recommendations.

1.4. Scope and Methodology

Quantitative and qualitative research methods will be used in the study. Firstly, the efficiency of POI will be compared with other ports by using Data Envelopment Analyse (DEA) method according to the container throughput as output. Because of the primary data limitation which has caused hesitations for sharing the commercial secrets of companies and insufficient data handling at public POI, the DEA will be based on secondary data of general specifications of the container terminals. This can be seen in many DEA studies in literature view.

Afterwards, Çandarlı Port project will be proposed as an alternative solution for POI and it will be financially analysed with the forecasted demand scenarios as a cost-benefit analyse. (CBA) The data will be collected from industry reports, national and international governmental organization's statistics or reports, journals, bulletins, and other databases. Literature view will comprehend the previous studies on container terminals with DEA and CBA. World Maritime University library databases, Google Scholar, academic articles and books are the essential resources of literature view.

CHAPTER TWO - INTRODUCTION TO PORT OF İZMİR

This section of the study will give information about the historical development of POI and the rehabilitation project. Additionally, the problem subject to the study and the research questions will be stated in this chapter.

2.1. Overview

İzmir is one of the oldest settlement with a more than 5000-year history at the west shore of Anatolia Peninsula which is also called Asia Minor. From past to present, it has been an important port city. Merchant trade and the port has always been foremost elements for shaping the city's identity, establishment of its original characteristics among other Turkish cities and for enrichment. The city has brought West and East together with trade connection for centuries. In old times, even from Iran or east Mediterranean cities camel trains were carrying authentic cargoes to İzmir for shipping them across the western Mediterranean. (Ari, 2011) In Ottoman Empire time the biggest part of the export was reaching to the West by İzmir port. (Frangakis, 2018)

Nowadays, in reference to the Turkish Statistical Institute (TurkStat) (2018) data population of the city was 4.3 million in 2017. However, according to the same reference, the population was 3.4 million in 2000. Just in 17 years, the population increased approximately 900 thousand and the city has been struggling about supplying adequate infrastructure because of this sudden improvement.

On the contrary to the current central location, POI was at the edge of the city close to the train station and industrial areas when it was built in 1954 and it was called with the name of close neighbourhood Alsancak. (Figure 3) Later on, it was delivered to the TCDD, public railway company in 1957. (İZTO, 2006) Then, it was transferred to public Maritime Bank in 1960. Afterwards, POI transferred to TCDD again in 1989. (TCDD, 2019) Finally, after the unsuccessful privatization practices, the port alienated to Turkey Wealth Fund Management in 2017. (Turkey Wealth Fund, n.d.)



*Figure 3. Port of İzmir
(Google)*

POI has a great location advantage because the port area is safeguarded from weather conditions and the port serves all year non-stop free from the bad weather. The current is lower than 1 knot and the tide is maximum 75 cm. There is no visibility problem in the gulf and the fog is as rare as to be ignorable. But this sheltered position of the port also the cause of its deficiencies. While the depth of the water is between 45-73 meter at the

entrance of the gulf. (Köktaş, 2007) It is between 10-12 meters at the approach channel and between 6-10.5 meters at the berths. (Dokay Ltd, 2016)

Although its main business is container handling, POI also serves for passengers, cars, general and bulk cargoes. According to the TCDD statistical data (2018), it has more than 1 million TEU container handling capacity per year. However, POI handled approximately 4-million-ton dry bulk and general cargo and 639 thousand TEU in 2017. When considered the container berth output in Figure 4. POI has lost its business since the 2008 financial crises. 2007 was the peak year for container throughput by 898,000 TEU. The port could not recover its business again after 2008 because of various factors like congestion at the port, growing vessels sizes and new competitors in the region.

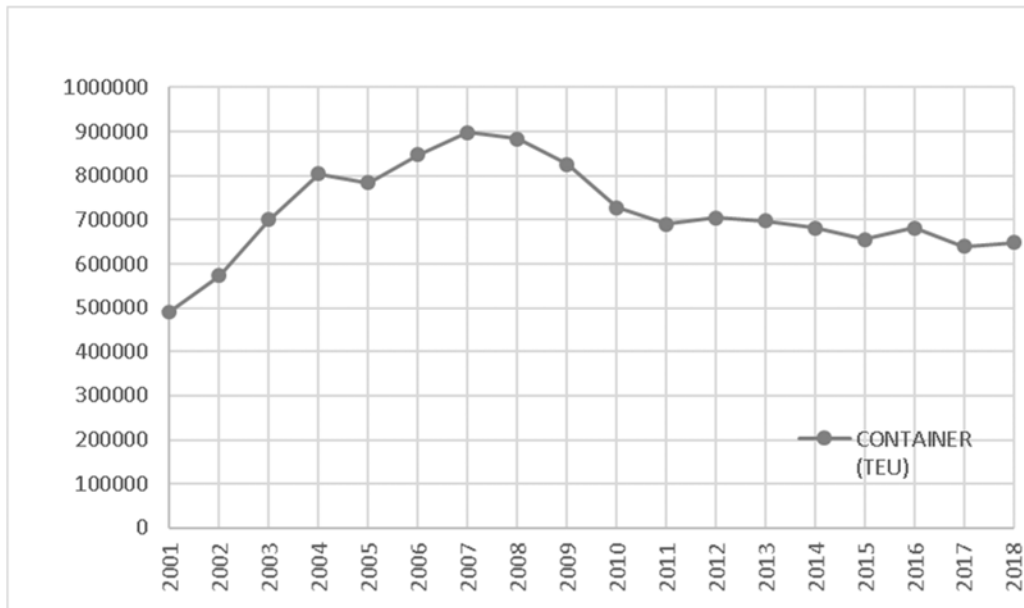


Figure 4. POI's yearly container throughput
(compiled from TCDD data)

Before 2009, when the POI reached the container throughput above the 800 thousand TEUs (2006, 848.000; 2007, 898.000; 2008; 884.000 TEUS), it was exceeding the

maximum capacity which is indicated 549 thousand TEU by TCDD in these years. Nevertheless, this capacity number was increased since the year of 2012 with some superstructure investments and small scale expansions at the port and today, the current technical capacity number is expressed 1.165 million TEU by TCDD.

When all-cargo handling throughput in tonnage examined, the containerization impact can be seen at POI. (Figure 5) Container and other cargo volumes in tonnage were so close in 2000. Then, the gap between them became wide and it was the highest gap in 2008. The port reached the maximum cargo tonnage throughput in 2004 and it was the lowest in 2008. But, in the same year container cargo in tonnage was at the peak.

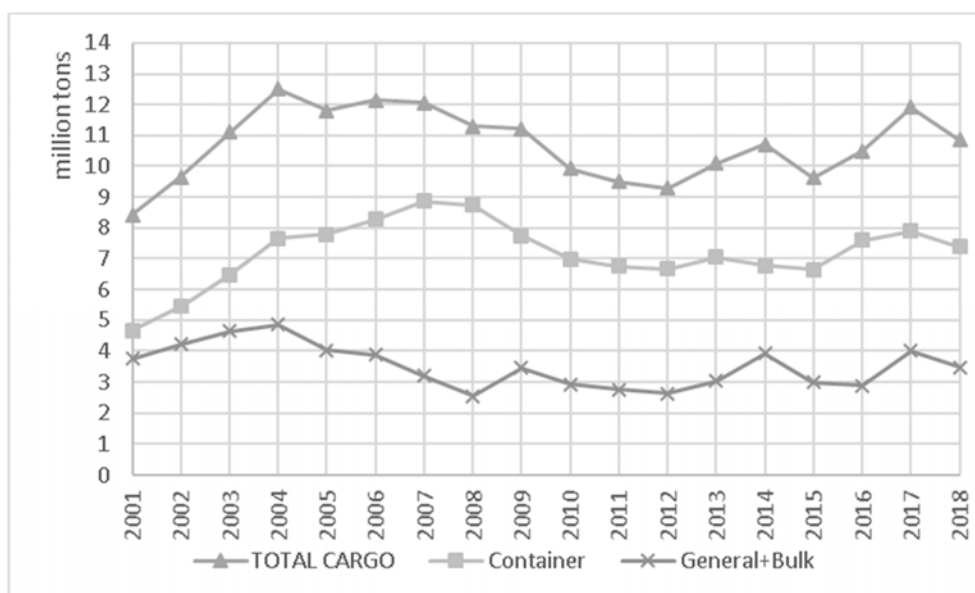


Figure 5. POI cargo volume in tonnes
(compiled from TCDD data)

Nevertheless, solely cargo throughput in tonnage cannot be a development criterion for a port. For instance, in the container shipping industry number of TEU is more meaningful

than the weight. In consideration macroeconomics, cargo value is more precious than cargo volume by its contribution to the national or regional economy.

On the other hand, POI was the main port of call for cruise vessels until 2015. The number of visiting passengers reached to half-million in 2011 and 2012 and the city was awarded as the leader cruiser destination in Europe for 2011, 2012 and 2013. (İZTO, 2019) Due to the terror attacks and coup attempt in Turkey, the number of calling vessels was decreased sharply and only approximately 10 thousand passenger visited İzmir with 18 vessel calls in 2017. (Figure 6) (İZTO, 2019) Nonetheless, in good years of cruiser tourism sometimes 4 vessels were berthing at the same time and more than 10 thousand people were leaving from them on the same day. Many of these tourists were carried to the close historical places like Ephesus ancient city or Mother Mary's House by buses. Therefore the departure and arrival of these buses from and to the port were creating traffic congestion in the city.

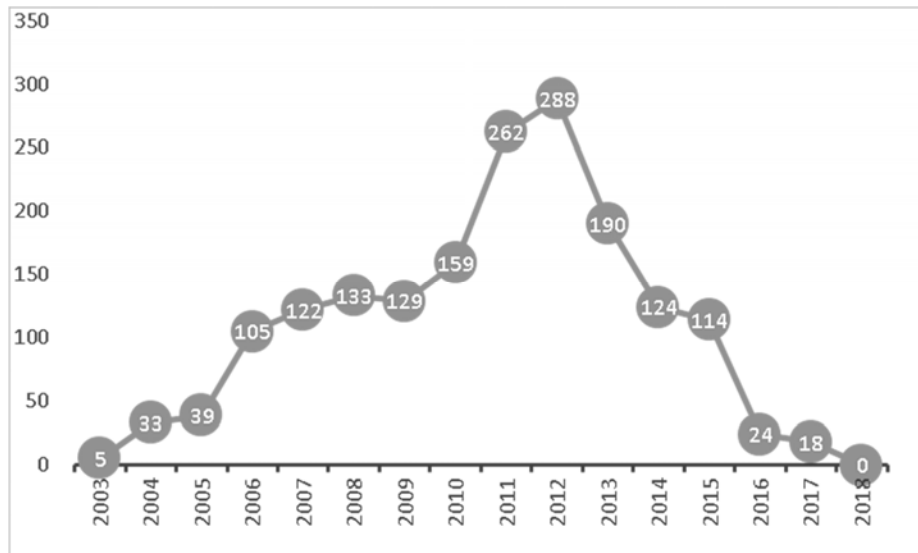


Figure 6. Yearly Cruiser Vessel Numbers at POI
(compiled from İZTO data)

POI has 24 berths with different dimensions and purposes: (Figure 7) 2 berths for passenger vessels, 10 berths for general cargo and dry bulks, 10 berths for container operations and 2 berths for dry bulk cargoes. (Table 1) The total berth length is 3386 meters. The depth of berths is varying between 6 and 10.5 meters. (Oral & Özerden, 2010)

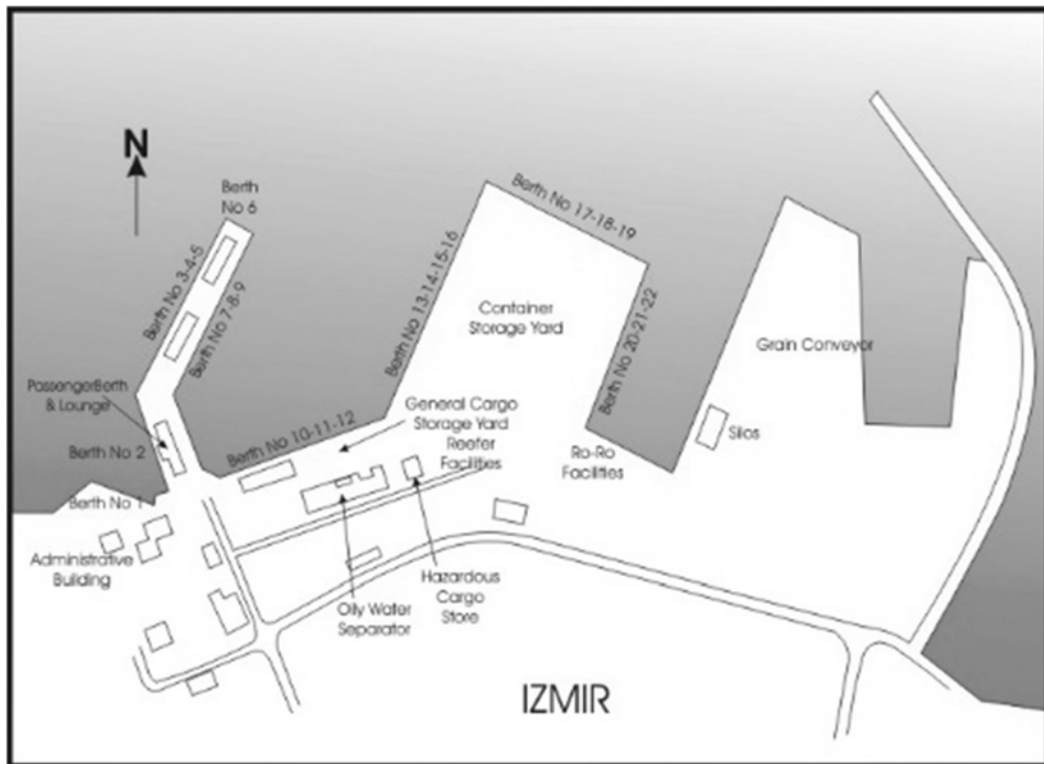


Figure 7. Layout Plan of POI

(UAB, 2014)

Table 1. POI Berth Specifications

BERTH				
#	PURPOSE	LENGTH (m)	WIDTH (m)	DEPTH (m)
1	Passenger	140	16	7.00
2	Passenger	191	16	8.50

3	General Cargo +Dry Bulk	139	20	10.50
4	General Cargo +Dry Bulk	125	20	10.50
5	General Cargo +Dry Bulk	153	20	10.50
6	General Cargo +Dry Bulk	75	31	10.00
7	General Cargo +Dry Bulk	125	20	9.50
8	General Cargo +Dry Bulk	120	20	9.50
9	General Cargo +Dry Bulk	127	20	9.50
10	General Cargo +Dry Bulk	127	13	6.00
11	General Cargo +Dry Bulk	97	13	7.00
12	General Cargo +Dry Bulk	125	13	8.00
13	Container	143	26	9.50
14	Container	143	26	10.00
15	Container	144	26	10.00
16	Container	170	26	10.00
17	Container	153	30	10.00
18	Container	144	30	10.00
19	Container	153	30	10.00
20	Container	117	30	10.20
21	Container	126	30	10.20
22	Container	121	30	10.20
23	Dry Bulk	212	20	10.00
24	Dry Bulk	216	20	10.00

(Oral & Özerden, 2010)

POI has a 90-ton capacity floating crane, 5 gantry cranes, 3 mobile harbour cranes (MHC), 15 reach stackers, 14 empty container reach stackers for container handling operations. Besides, it has 6 mobile cranes for other operations. Nevertheless, there are 4 other MHCs which are outsourced from shipping lines.

POI has 525 thousand m² total area and 25 thousand m² close area. Container stockyard is approximately 250 thousand m². (Arisoy, 2017) It has 251 white collar and 385 blue-collar employees in 2018. (TCDD, 2018) The services are provided non-stop with 3 shifts.

When the revenues and expenditures of POI examined according to the TCDD data, it made a profit all the years between 2003-2017. (Table 2) In this period, the highest revenue was obtained in 2017 and except 2005, 2007 and 2010 the revenues are always increasing. The highest expenditure in 2017. Except for the year 2016, the expenditures are increasing every year, too. Consequently, the highest profit is in 2017 by approximately 190 million TRY.

Table 2. POI Profit Loss Table

YEAR	REVENUE (TRY)	EXPENDITURE (TRY)	PROFIT/LOSS (TRY)
2003	103,295,199	29,878,979	73,416,220
2004	118,168,481	36,611,088	81,557,393
2005	118,096,960	40,329,365	77,767,595
2006	142,431,635	41,711,912	100,719,723
2007	131,007,714	46,968,374	84,039,340
2008	144,866,485	47,790,808	97,075,677
2009	144,954,816	48,551,320	96,403,496
2010	138,947,337	71,401,053	67,546,284
2011	149,000,189	77,475,850	71,524,339
2012	157,411,646	78,202,491	79,209,155
2013	165,401,212	82,426,705	82,974,507
2014	205,205,995	100,878,440	104,327,555
2015	233,179,951	121,415,841	111,764,110
2016	270,541,845	115,049,799	155,492,046
2017	311,857,137	120,497,162	191,359,975
2018	382,152,500	136,861,388	245,291,112

(compiled from TCDD data)

2.2. Competitors

Until 2008, POI's container throughput showed a big shift with increasing demand. During this term, the users and the port faced challenges about services because of the inefficiencies and congestion in both port and city. Hence, some non-maritime industry facilities which had ports for their businesses invested in their ports to convert them container terminals, too. Eventually, two container terminals have begun their services at the end of the first decade of the millennia. Ege Gübre Port and Nemport are located just 50 km north of İzmir city. They are away from residential areas and they have proper highway connection. Nevertheless, railway connection is not linked directly into the ports but they have a very close railway logistics station. That station and railway link construction to the Nemrut Bay has been completed in 2017. Besides, in the same year the third player, Socar Terminal container terminal joined the competition in the region. (Figure 8)

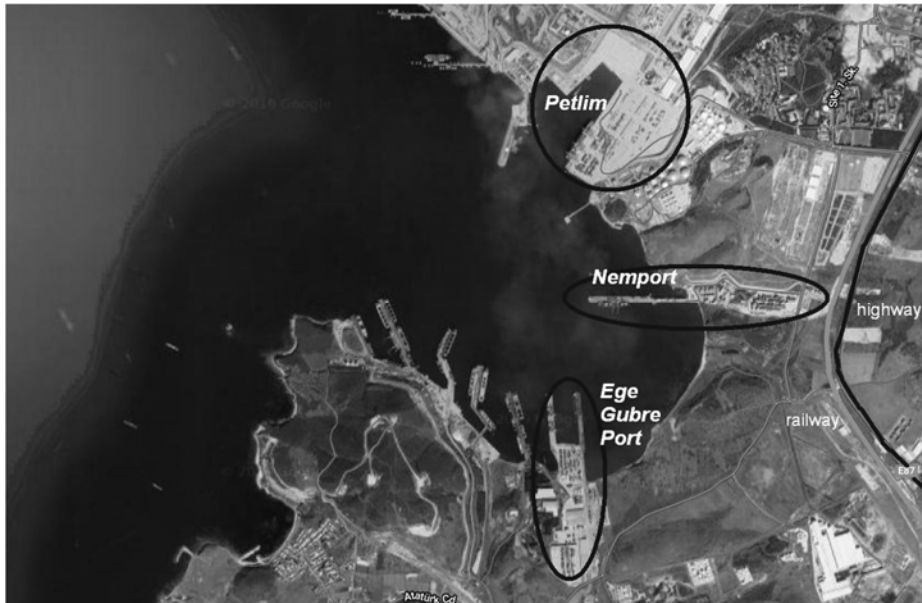


Figure 8. Nemrut Bay Container Terminals

(Google)

These new container terminals' container throughput developed rapidly. They do not have any draft problem and vessel size restrictions in compare to POI. Socar Terminal was directly operated by A.P. Moller Terminals. But the terminal is owned by Socar Company which bought the Petkim Petrochemical Industries by privatization in 2007. Before it was expanded and built the port was the general cargo berth of Petkim Petrochemical Industries. Figure 9 shows the total container throughput of these three container terminals annually.

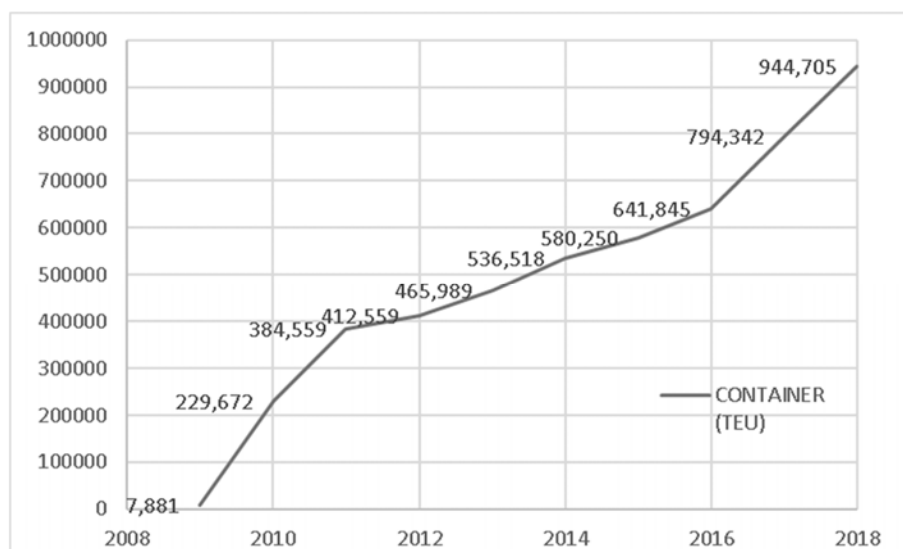


Figure 9. Total container throughput of POI's three competitor ports
(UAB, 2019)

When considered there are expansion plans for POI since 1973, it is obvious that these new container terminals have the advantage of being belonged to the private sector. They are not managed indirectly with governmental programs as POI. Hence, their management can decide the required investments and do them timely. For instances, by the preparation of this study Nemport is at environmental impact assessment processes stage for its port expansion and land reclamation project. Already, these three ports are the result of fast

decisions about assessing an opportunity about customer dissatisfactions caused by POI's insufficient capacity and services.

When the three competitor ports compared with POI the preeminent different feature is clearly the depth of berths. The minimum depth possibility among them is at Socar Terminal and it is -16 m. Nonetheless, Socar Terminal has the biggest gantry cranes which have 51 m height and can serve the vessels up to 18,000 TEU. (Socar Terminal, 2019) As shown in Table 3, Socar Terminal has the highest capacity container terminal among the four ports. Besides, there is not another container terminal at the Aegean shores of Turkey apart from this quartet. The closest container terminals at the north and at the south are Bandırma and Antalya. Their distances to POI are 270 nm and 400 nm at sea, respectively.

Table 3. Container Terminal Technical Data of POI's Competitors

	EGE GÜBRE	NEMPORT	SOCAR TERMINAL	POI	3 Competitors Total
Capacity (TEU)	400 000	750 000	1 500 000	1 165 000	2 650 000
Total Berth Length for Container Handling (m)	705	840	700	1 400	2 245
Average Draft (m)	-17	-17,5	-16	-10	-16,8
Container Stockyard (m ²)	240 000	160 000	400 000	250 000	800 000
Gantry Crane (STS)	2	2	3	5	7
Mobile Harbour Crane (MHC)	2	5	0	7	7
Total Berth Crane Capacity (ton)	300	670	210	900	1 180
RTG Number (stockyard)	6	5	10	14	21
Reachstacker	4	8	3	15	15
Empty Container Handler	3	5	3	14	11
Truck	18	30	26	49	74

(compiled from various sources)

2.3. Hinterland

Turkey is divided into seven big regions. The partition is not related to the administrative organization of government but because of the geographical and sociocultural similarities inside them, they are important for planning and decision making. Three competitor ports

are in the same bay and they are just 50 km away from POI. Hence, it can be said all the four container terminals are serving almost the same hinterland mainly Aegean Region of Turkey. Thus, they are using the same highway and railway connections within the hinterland. (Figure 10) In the Aegean region, the mountains are located vertically to the sea. Hence, the transportation has been developed well since the 20th century. Most of the railway network is built before the foundation of the modern Turkish Republic to connect port city İzmir to the main agricultural centres at the inside lowlands. The first railway in Anatolia was built between İzmir and agricultural city Aydin. The inland waterways are not convenient for vessel transportation in the hinterland. There are seven airports in the region. The biggest of them is İzmir Airport.

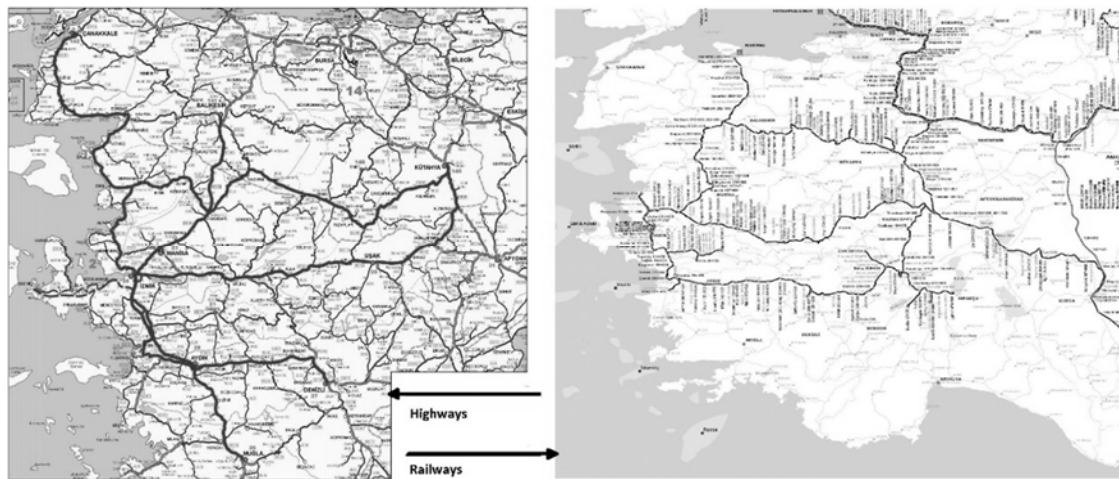


Figure 10. Railway and Highway Connections

(UAB, 2014)

Nevertheless, the hinterland is not restricted with just Aegean region. West north parts of Mediterranean, west south of Marmara and some western parts of inside Anatolia regions are also sending cargoes to Aegean ports. In a study by Baran (2008), it was found that 54% of the cargo was from the Aegean region for POI and a total of 36% cargo was from Marmara and Mediterranean regions. Westside of middle Anatolia region was providing

approximately 8% of the cargo. Even small amounts of cargo from the east side of Turkey was sending to POI although there are closer alternatives like Mersin Port. On the other hand, this research is dated a period when the POI was the second biggest container terminal in the country and its throughput was over than 800 thousand TEUs. Besides, the new container terminals in Marmara region close to the big industrial cities like Ankara, Bursa, Bandırma, Balıkesir have not been opened yet. The privatization of public ports was not completed and only the Mersin Port was just being privatized in 2007 during the mentioned research period.

Aegean region has the longest shores in Turkey because of its indented shape. In history, many civilizations located in these safe gulfs and bays at region's shores. İzmir is one of the oldest and third biggest cities in Turkey and it is the trade and industrial centre of the Aegean region. Also, the Manisa and Denizli developed in the industrial business. In 2017, the total export of the region in value was approximately 16 billion USD and export revenues were increasing regularly until 2012 except the 2008 financial crises. (Figure 11)

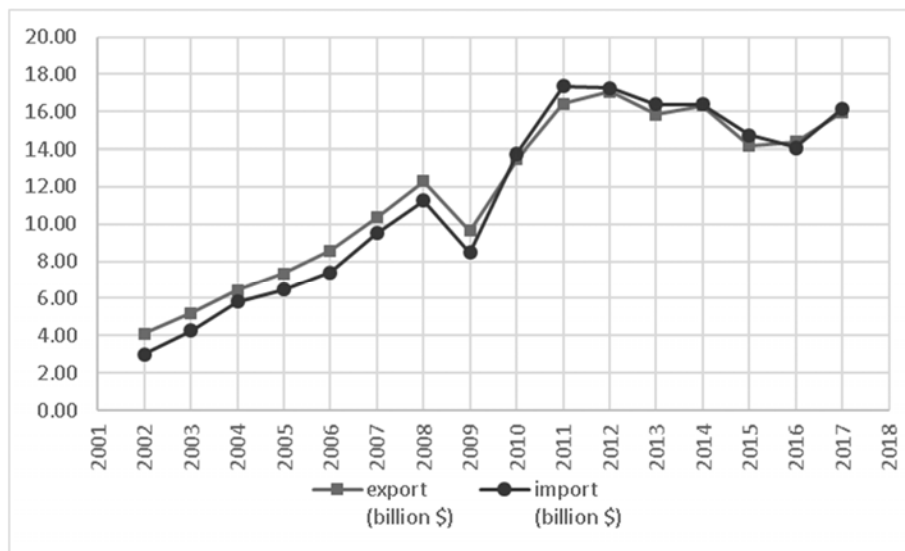


Figure 11. Export and import in the Aegean Region of Turkey
(TurkStat data)

In 2018, the total population of eight cities in the Aegean region has been counted over than 10 million. (TurkStat, 2019) The total area of the region is 90,000 km². When the annual population of the region is examined, a linear increase can be seen in Figure 12. İzmir is the biggest city in the region in terms of population. The close neighbour cities Manisa and Aydın are following the İzmir. (Figure 13) Nevertheless, another important industrial city Denizli also has a population of over 1 million. The fifth populated city Muğla's population is variable seasonally. The current number was calculated according to the continuous habitants of the city. Muğla also includes the touristic centres like Bodrum, Marmaris, Fethiye, and Milas. So the summer population will be exceedingly different.

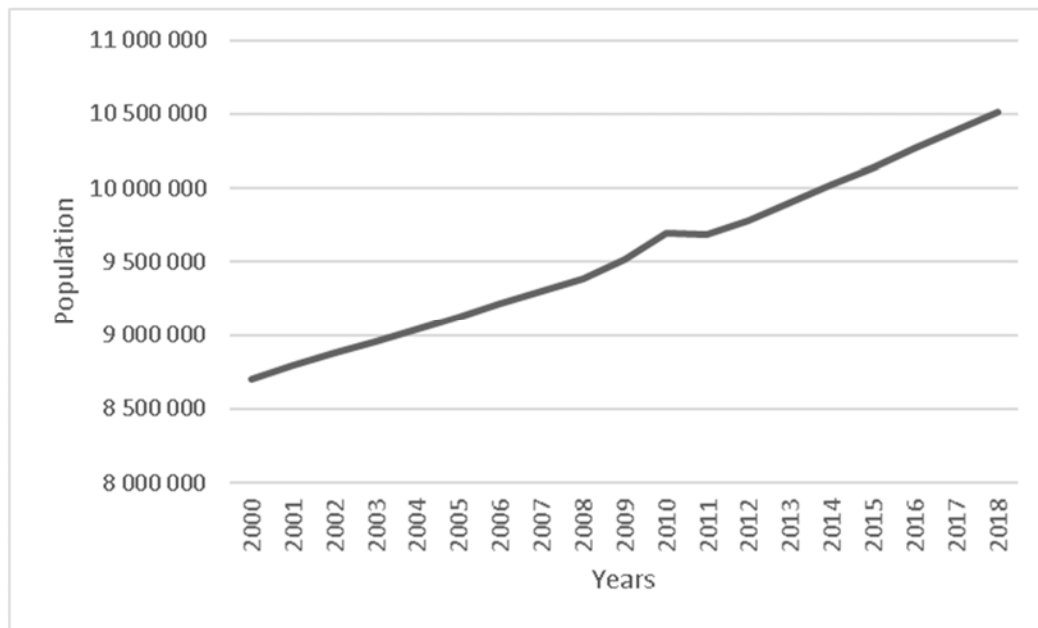


Figure 12. Population changes in Aegean Region
(compiled from TurkStat data)

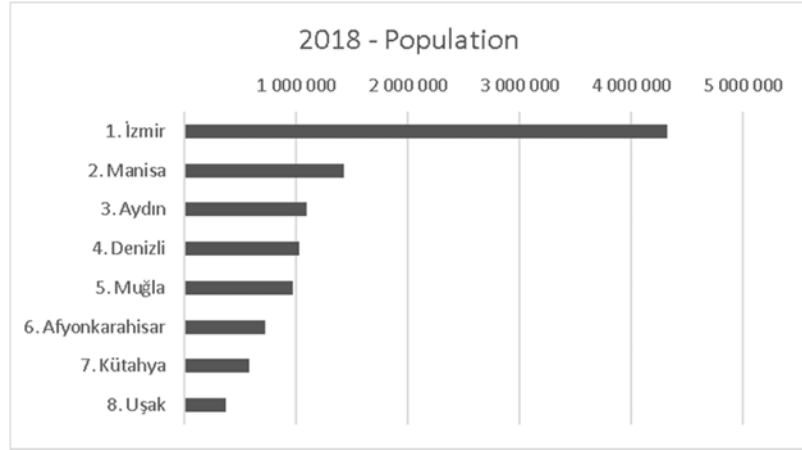


Figure 13. City populations of Aegean Region
(compiled from TurkStat data)

In recent years, especially the population of İzmir increased incrementally. It can be seen clearly in Figure 14. In just 18 years the population increased by approximately 1 million. Another city in the region, Kütahya has lost population in the same period. But it is the only city with reducing population among them.

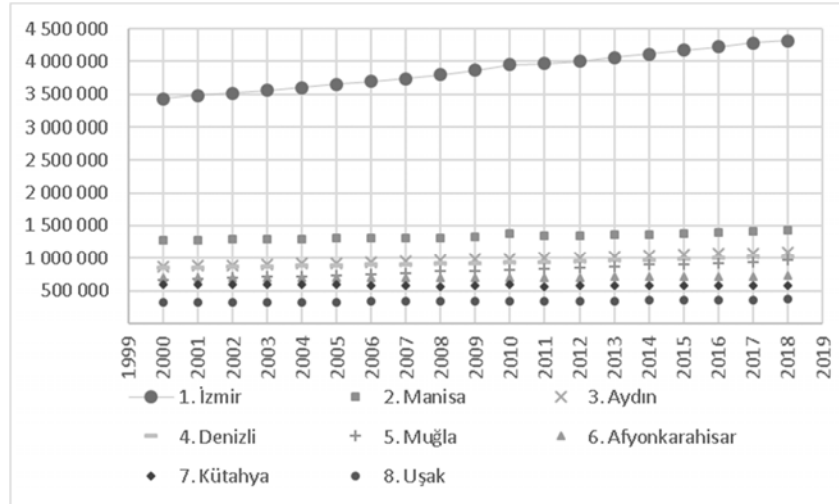


Figure 14. City population changes
(compiled from TurkStat data)

Agriculture has always been important in the region since centuries because of rich soil and proper climate conditions. When total plantal and animal product production was lower than 1 billion TL in value terms in 1995, it has been over 30 billion TL in 2018 according to TurkStat data. (Figure 15) When the total agricultural production is considered in tonnage, the Aegean region's increase ratio is higher than Turkey's total. In the last 24 years region's agricultural production in volume has increased 279%, however, Turkey's total agricultural production has increased by 213%. (Figure 16) Nevertheless, in 2018, 6.5% of Turkey's total agricultural product was generated by the Aegean region.

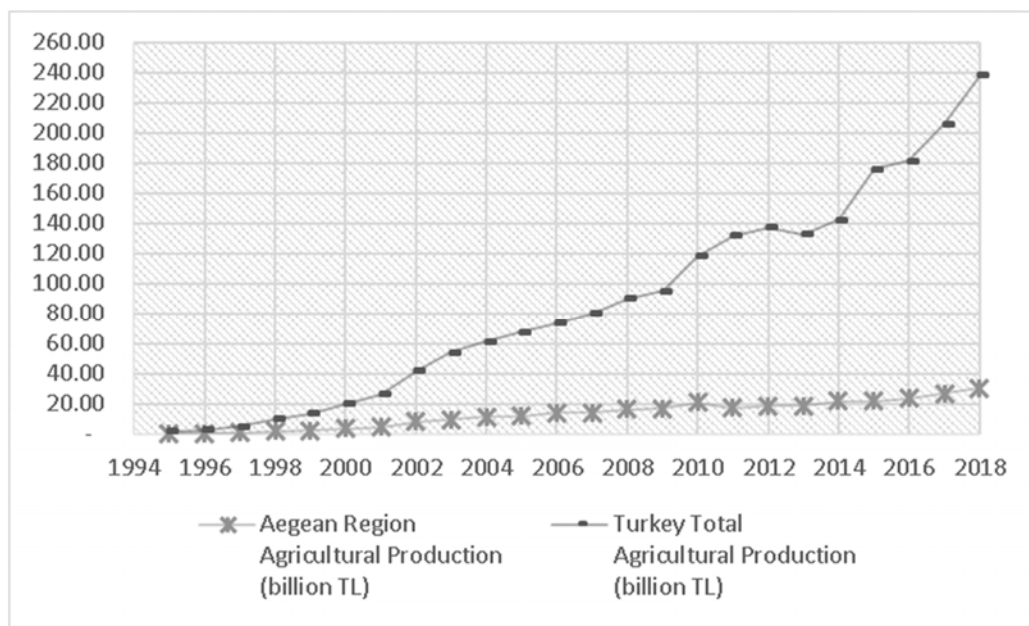


Figure 15. Agricultural production in value
(compiled from TurkStat data)

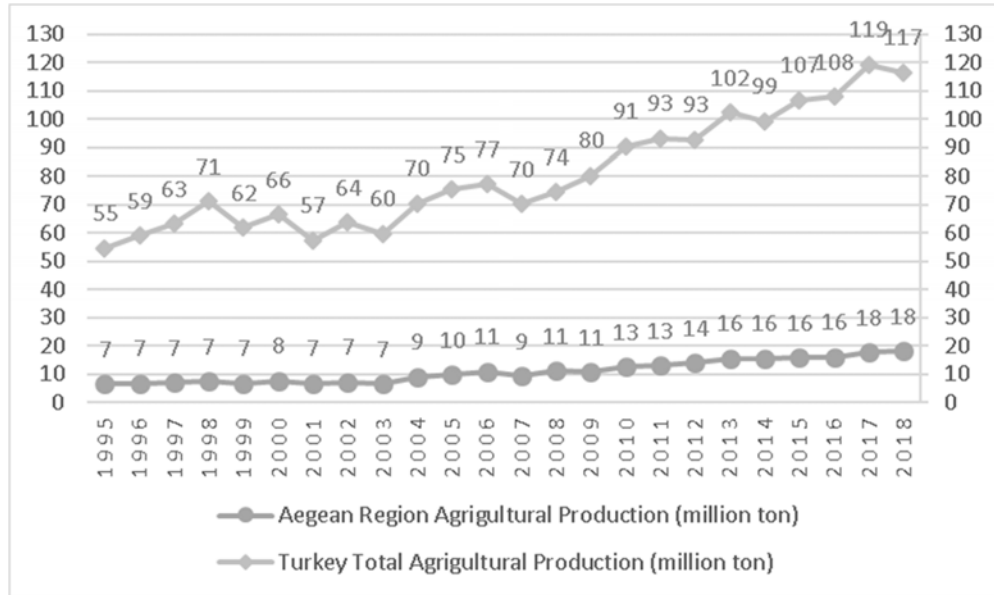


Figure 16. Agricultural production in volume

(compiled from TurkStat data)

The biggest part of Aegean Region's GDP has been services for many years. According to the TurkStat data (2018) in 2017, the services industry gross production was 185 billion TL. Besides, as shown in Figure 17. the ranking of industries in GDP has not changed since 2004. Also, the industrial GDP has been an important output for the region's economy.

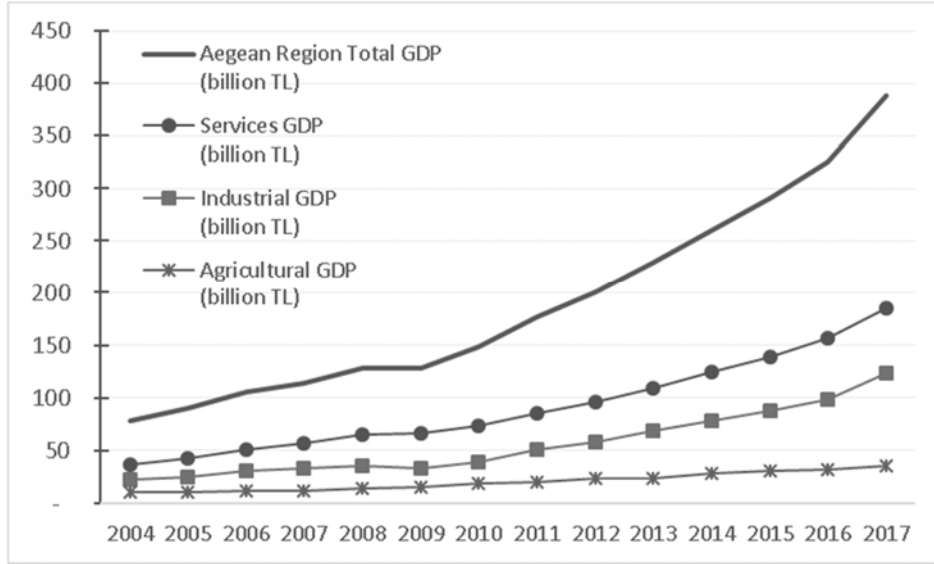


Figure 17. Aegean Region GDP growth
(compiled from TurkStat data)

2.4. Rehabilitation Project of İzmir Bay and Port (Great Gulf Project)

Gulf of İzmir had faced the shoaling problem for many years. And there is a eutrophication matter in the cove because of the high sediment input from several streams. Change of the Gediz riverbed prevented the closing of the cove in 1886 but the problem of shoaling and due to this, the decreasing quality of water because of low water circulation could not be eliminated. So, aside from the environmental aspect, also the maritime business has been impacted negatively. POI berth design drafts have decreased 1-2 meter since their construction in 1954. Nowadays, especially the new generation bigger container vessels cannot call POI. Municipality of İzmir's first step for preventing pollution and increasing water quality in the bay was the Great Channel Project which stopped any discharge of wastewater from city to sea in the 1990s. Then, the municipality carried out some dredging operations for ecological reasons, for instance, to keep the fisheries. These dredging operations were small scale works and the dredging material did not cause any problems.

Then, the municipality has watched the currents and water features of the bay at 16 points since 2011 incorporation with Dokuz Eylül University. (İzmir Water and Sewerage Administration [İZSU], 2019)

After the unfruitful privatization practise in 2009, the central government planned to invest in POI to make it an attractive destination for shipping lines again. Hence, the İzmir Municipality and Public Railway Company signed a protocol about cooperation for dredging operations in the gulf. Hereunder, the municipality will dredge a 13.6 km length, 250 m width and -8 m depth water circulation channel at the north side of the bay. TCDD will be responsible for dredging the approximately 12 km length, 250 m width and -14 m depth approach channel and port basin and construction of second container stockyard and berths by land reclamation. Likewise, construction of extra superstructure facilities at the POI. (Figure 18)



Figure 18. Rehabilitation Project of İzmir Bay and Port

At the environment impact assessment report of the project, it is mentioned that approach channel will be dredged -14 m at the first phase and the depth can be made -16 and -17 in future. Same dredging depths are calculated for port basin and manoeuvring room. 1.8

million m³, 24.84 million m³, and 7.6 million m³ material will be dredged from approach channel, circulation channel and port basin and manoeuvring room respectively. (Dokay Ltd., 2016) Evaluation of dredging material is a matter of debate about the project. The total amount of salty mud will exceed 35 million m³. It is planned to build two artificial islands in the bay with dredging material. And some amount of it will be used land reclamation for the second container stockyard and berths at the port. The remaining amount will be discharged to the sewage treatment plant purification area to use as a filling material shore constructions works in the city. An extra container stockyard and two passenger terminal berths will be built at the port. The container handling capacity will approximately reach to 2 million TEU. And berth drafts will be -14 m. (Dokay Ltd, 2016) (Figure 19)



Figure 19. POI layout plan after rehabilitation project
(Oral & Özerden, 2010)

2.5. Background and the Statement of the Problem

POI has draft problems for long years because of the intense sediment input to the bay of İzmir. The first dredging was made in 1984 to the approach channel of POI. Then, in 1986 a dredging was carried out at Melez stream delta which is side by side the port facilities. In 2001, improvement and dredging were made at Melez stream delta again. In 2010, the municipality practised general dredging and cleaning at the stream mouths. (Dokay Ltd, 2016)

Container vessel sizes are growing up because of the high competition in the industry. (Figure 20) Hence, the ports which have draft problems are under pressure of new bigger vessels. POI is suffering from the approach channel depth and insufficient drafts at berths. The new bigger container vessels cannot call POI because of these draft problems. Therefore, the containers are transhipped to the smaller feeder vessels and transported to the POI. Transhipment of cargoes means extra costs for shipping lines and shippers.

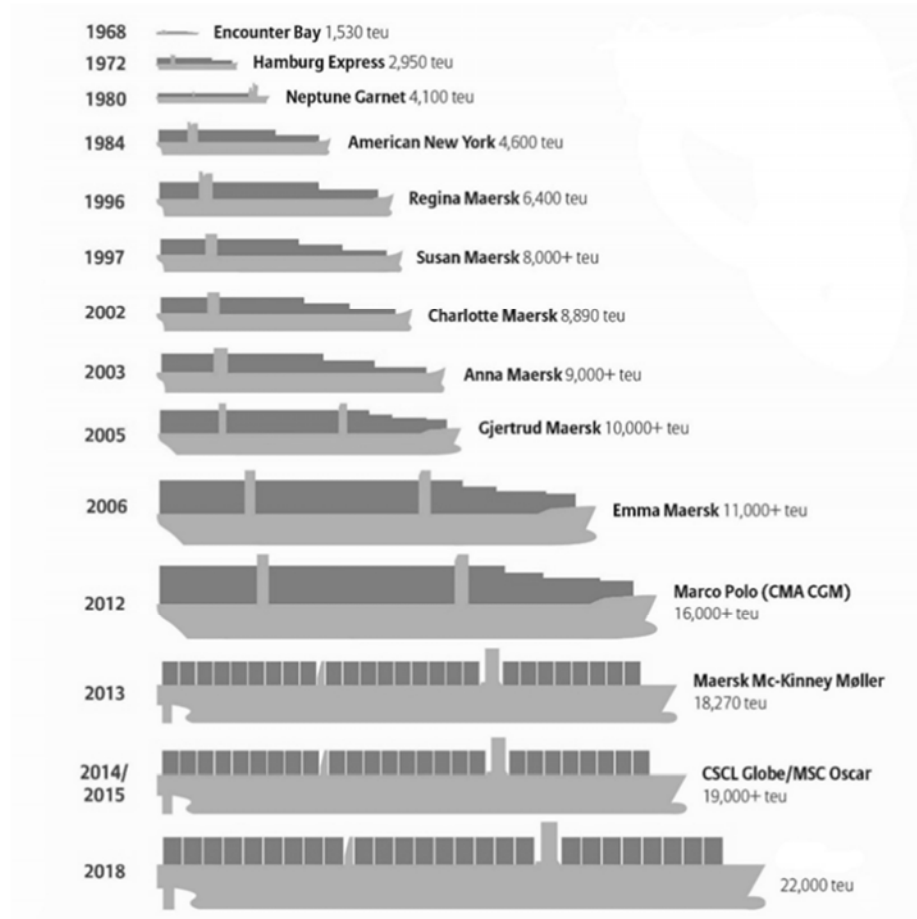


Figure 20. Container vessel size growths
(WSC, 2018)

Beside depth insufficiencies, there are other problems with POI which are playing the second fiddle for now. POI is at the centre of a rapidly growing city. The population and habitation are increasing swiftly but the infrastructural development of İzmir city cannot suffice to population increase. The road network is not distributed regularly and existing roads are narrow. They are stopped with many traffic lights at many intersections. Furthermore, the POI does not have a direct access road outside the city and the trucks have to deal with the city's traffic congestion. (Figure 21)



Figure 21. Heavy traffic at POI side road

(Timeturk, 2017)

The rehabilitation project is just about POI's draft problems and there is not any current plan to solve the inland access problems of the port. When considered hundreds of containers are carried in and out of the port by trucks daily, by increasing capacity of POI in future the truck traffic will also increase exponentially. Nevertheless, POI is in the middle of the city where covered with residential areas, hence it is not possible to build a separate road which just serves to port and connect it highway networks outside the city.

Nowadays, the port concept is evolving. Ports are not places to just load or unload cargoes on board of vessels. Value-added services like storage, packaging, labeling and custom clearance are important for port competitiveness. In developed countries, logistics centres are located alongside the ports. For instances, ZAL Port which is the international logistics hub of the Port of Barcelona is just located around the port. (ZAL Port, n.d.) And Port of Barcelona is one of the leading container terminals in the Mediterranean region with 3.5 million TEU annual throughput in 2018. (Port of Barcelona, 2019). In this respect, POI

has no possibility to have a logistics centre around. It is covered with residential areas of the city. Besides, it is impossible to connect with inland logistics centres without efficient road and railway links. Furthermore, İzmir city management is making time restrictions about trucks to enter in the city. Trucks are not allowed to enter into the city centre between 07:00 – 10:00 and 16:00 – 20:00 when the commuters traffic is intense. This restriction has a negative impact on cargo transfers into and out of a non-stop working port. But it is necessary to ensure the safety and flow of passenger transportation in the city.

Meanwhile, cost of the project is unclear. The indicated amount by TCDD is 800 million TRY and it was approximately equal to 280 million USD in the year of project preparation. Nevertheless, although the real cost was not published by Port of Melbourne Corporation it was projected as 969 million Australian Dollar (which was around 800 million USD in September, 2008) for a total 23 million m³ dredging operation to increase the draft availability from 12 m to 14 m in Port Phillip Bay, in Australia, in 2008. (Parliament of Victoria, 2008) It means more than 30 USD cost for one cubic meter dredging. There are some other port dredging sample cases which cost 18-20 USD per cubic meter. In İzmir Bay and Port Rehabilitation Project total amount of dredging material is around 35 million m³ for the first phase and if it is benchmarked with mentioned other cases just the dredging cost forecasts should be between 500 – 900 million USD depending on the material type. And, POI's project will include extra costs for land reclamation and new berth constructions.

There is another big port project just 90 km away from İzmir. Çandarlı Port will have 4 million TEU capacity when completed. Firstly, it was designed as a mega-hub port with 12 million TEU capacity, but, because of the recession in the container shipping industry after the 2008 financial crises the project revised and the capacity reduced. Çandarlı Port can also serve both national export-import and international transshipment cargoes with its reduced 4 million TEU capacity. The total cost of the project was calculated as 910 million

€ 1500 m long breakwater already completed and road links are under construction. (Figure 22) The remaining infrastructure and superstructure of the project were bided at the end of 2013 as a build-operate-transfer (BOT) model but there was not any bidder. Therefore, the project cannot progress at the moment because of financial matters.

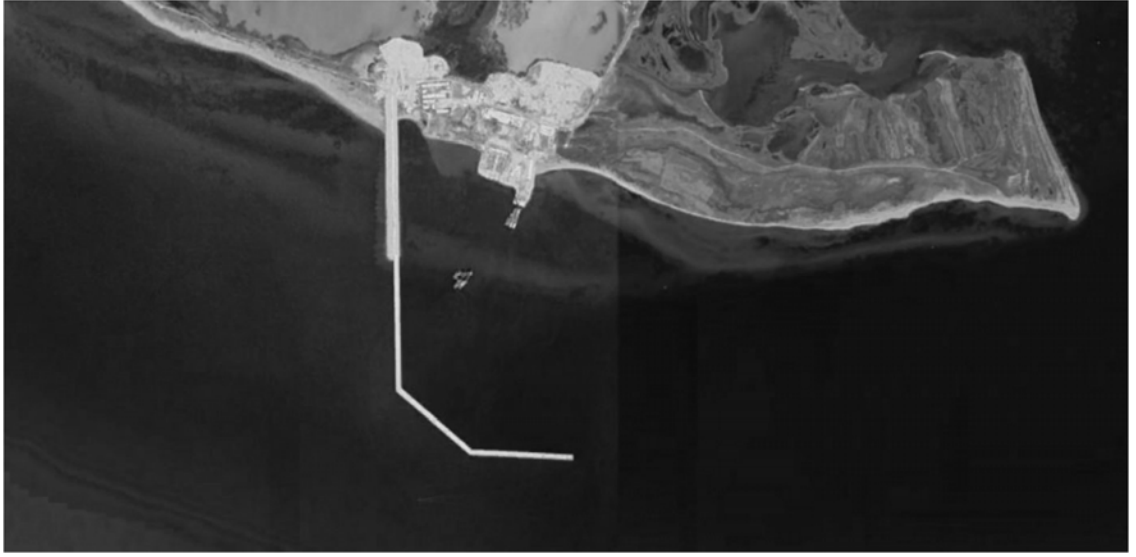


Figure 22. Çandarlı Port breakwater
(Google)

In conclusion, the expensive approach channel and port basin dredging project may provide high drafted vessels to call POI in the short term, but unsolved inland connection problems will still make the POI weak in competition. Hence, big investment to rehabilitation project may not provide the expected return. Besides, POI will need continuously dredging in the future to keep the drafts stable or extra deepness requirements. Incomplete Çandarlı Port has a great potential to serve both local and transshipment cargoes. Nevertheless, Çandarlı Port can obtain transshipment cargoes from its close competitor Pireaus Port, which is 200 miles away, with cost-efficient smart technologies and automated handling equipment. It does not have current and future draft

problems by it is planned -18 m berth depths. It is away from residential districts and it can connect to close highways and railways. But it is not feasible and financially possible to conduct both POI rehabilitation and Çandarlı Port projects in Turkey's current economic situation and hinterland's container throughput.

2.6. Research Questions and Hypotheses

In the shipping industry, performance and cost-efficiency are important for competition when there are multiple suppliers and limited demand corresponding to the supply. POI was the only container terminal at the Aegean region of Turkey for long years and it was not in competition for transshipment cargoes with foreign ports. Hence, the efficiency has been ignored; the required infrastructural and superstructure investments have been postponed.

In this manner the study will seek answers to the following questions:

- What is the POI's current performance in comparison of other container terminals?
- Will the POI dredging and investment projects be feasible in the future?

Additionally, the study will present and uphold Çandarlı Port investment as an alternative solution for POI's problems and will seek an answer if it is feasible to invest in Çandarlı Port instead of POI.

CHAPTER THREE – LITERATURE VIEW AND METHODOLOGY

This chapter will establish the theoretical framework of the study by examining existing methods and past researches on similar port performance and investment analysis. The first phase of the chapter will be about measuring the container terminal efficiency. Then, the investment appraisal methodology will be presented.

3.1. Port Productivity and Efficiency

Productivity, efficiency, effectiveness, utilization and performance concepts are often expressed at daily business transactions sometimes without knowing what actually they mean. Especially, it is really uneasy to make sense of productivity and efficiency. The generally well-known definition of productivity is simply the ratio of output to the input.

$$\text{Productivity} = (\text{Output Obtained})/(\text{Input Spent})$$

González and Trujillo (2009) associate the efficiency entirely with productivity. Lopez-Bermudez et al. (2019) argue the same idea, on the other hand, they stated that both concepts are not synonymous. According to Ashe-Edmunds (2019), the basic clarification of productivity and efficiency can be explained by quantity versus quality. He puts emphasis on the quality of work and according to him, quality includes less waste production and use of fewer resources. When viewed from this aspect, efficiency is more related to what can be produced than what really is produced. Hence, productivity

measures the current use of capacity but efficiency measure is the ratio of actual output to the achievable output.

$$\text{Efficiency} = (\text{Actual Output})/(\text{Achievable Output})$$

Productivity and efficiency measurements are clearer for industrial tangible production than the service industry. Basically, services are not produced at an assembly line with certain inputs. For instance, when a salesperson sells three property at one month makes him efficient in comparison of the previous month's two property sale volume for the same person. (i.e. we can call him, he is efficient this month.) However, his five property sale in next month will make this month again inefficient. The time is one month, the labour is one person. And there is a possibility of his higher effort levels for fewer sale months. Many similar examples can reproduce for the service industry. In short, identification or calculation of the standard output (achievable output/maximum output) is not possible in every case, especially for the service industry's intangible product: the services.

In addition to this, there is another dimension of efficiency and productivity measurement: the cost or price. As yet, the relation between the number of inputs and outputs are compared for explanations of efficiency and effectiveness. However, when there are multiple input-output choices the lowest input with the highest output may not be the most efficient option every time because of the costs. Another choice, which is not volume efficient, might be the cost-efficient one. As a result of mainly price based and global scaled competition, the cost efficiency is more competitive than volume efficiency in many industries. For instance, a greater amount of energy can be produced by burning high viscosity fuels than by burning low viscosity fuels. But, because of the cost factor, heavy and slow steaming vehicles prefer low viscosity fuels. Thus, they are cost-efficient and more competitive to satisfy the needs of demand.

In summary, if there is more than one input, the choice of optimal input combination is called as allocative (price) efficiency. However, to obtain a maximum output with a certain volume of input is called technical (productive) efficiency. (Farrell, 1957) Nevertheless, effectiveness concept simply can be explained by doing the right work while efficiency is doing the work rightly. In this aspect, effectiveness is more related to beneficial results of outputs or processes. Effectiveness can indirectly contribute to efficiency by choosing the right (effective) inputs.

In many references, seaport services are divided into two main parts: services to vessels and services to cargoes. De Monie (1987) associated the port performance with three factors: ship stay duration at the port, cargo handling quality, quality of service to inland transport vehicles. Nevertheless, all these three factors are linked to each other. For instances, while discharging the steel roll from the vessel by shore crane directly to the truck haulage, this port handling service includes all of the three elements identified by De Monie. Either general seaport concept or container terminals, the productivity of these three performance elements will increase the total throughput (i.e. output) and productivity of the port.

In his UNCTAD monograph study, De Monie (1987) indicated that it is a challenge to analyse a port's performance because of the lack of up to date, factual and reliable data, the sheer numbers of parameters, absence of generally accepted definitions, esoteric influences of local factors on data obtained and divergent interpretations of the results. As before mentioned, identification of inputs and calculation of their contribution to the output is quite tough. Nowadays, in container shipping industry annual throughput of the port is the main indicator of the terminal's success. Absolutely, all the operations, equipment and crane capacities, berth availabilities and technical capacities of berths have direct or indirect effects on the total throughput. Hence, it is generally accepted to use superstructure and infrastructure capacity of the container terminal as inputs to evaluate port performance.

3.2. Data Envelopment Analysis (DEA)

There are three types of efficiency measurement methods. They are ratio analysis, parametric and non-parametric methods. Traditionally, ratio analysis is the proportioning of the output to the input. Parametric methods are based on regression analysis. They search a linear relation among dependent and independent variables. (Ateş & Esmer, 2014) To use the parametric method there should be a functional relation among inputs and outputs and the sample should have the features of the population. Hence, the variables should be distributed normally. In contrast to parametric methods, non-parametric methods are independent of the distribution and they do not make assumptions about population.

Cullinane, Song, Ji, and Wang (2004) defined DEA as a non-parametric method to measure the efficiency of more than one decision-making unit (DMU) with multiple inputs and/or multiple outputs. As the aforementioned efficiency explanation, it is not possible to obtain an absolute maximum output level for certain inputs in the service industry. Hence, DEA makes a relative efficiency measurement among similar DMUs. The best observations of the DMUs are indicated the frontier and other DMUs' efficiency is measured according to their distance to the frontier. The efficiency measurement in DEA is based on the ratio of weighted total outputs to the weighted total of inputs and any DMU's efficiency can be formulated as (Sülkü, 2011):

$$\frac{u_1 y_1 + u_2 y_2 + \dots + u_n y_n}{v_1 x_1 + v_2 x_2 + \dots + v_m x_m}$$

In the formula for the j^{th} DMU, there are “n” number of outputs and “m” number of inputs. The “u” is the weight of output and the “v” is the weight of input. So, the “y” corresponds the amount of output and “x” is the amount of input. (Sülkü, 2011)

DEA enables the measurement of the efficiency with inputs and outputs independent from production function and in DEA, the efficiency is evaluated relative to the most efficient

DMU, not the average efficiency function of DMUs like in parametric methods. Hence, it provides a better analysis of the maximum output level indication problematic in efficiency measurement. On the other hand, DEA makes it possible to use different inputs and outputs with different unit of measurements. However, it measures the efficiency at a specific period of time when the inputs and outputs are generated. Hence, an efficient DMU may be inefficient at another specific period of time.

In DEA, the methods may be input or output-oriented. Thus, when it is input-oriented the outputs will be constant and the analysis will be based on the changes at inputs. Vice versa, when it is output-oriented, the inputs will be constant and the changes at outputs will be examined.

The first base studies about DEA was held by Farrell in 1957. Then, Charnes, Cooper, and Rhodes developed the CCR method in 1978. Lastly, Banker, Charnes, and Cooper developed the BCC method for DEA analysis in 1984. Song states that (1999) the returns to scale of a production function point out what happens to output when all units are increased proportionately. The result can be constant, decreasing or increasing returns. CCR-DEA method based on a constant return to scale and BCC-DEA method based on the variable return to scale.

The first stage of DEA is the determination of homogenous DMUs for efficiency measurement. There is no rule for the number of DMUs but if the DMU number is less than the total number of input and outputs more DMUs will be efficient, hence it will be harder to distinguish the efficient DMUs. Then the inputs and outputs should be specified and their data should be collected. Lastly, the method of DEA is indicated and efficiency scores are calculated. Then, they are interpreted. The highest performed DMU's efficiency score will be 1 and relatively inefficient DMUs will be scored between 0 and 1. These scores will indicate their performance by benchmarking to efficient DMUs.

In their passenger port efficiency measurement study Güner and Coşkun (2014) modelled the basic input-oriented DEA as follow;

The objective function (maximization of output):

$$\max \theta = \sum_{r=1}^n u_r y_r$$

$$\max \theta = u_1 y_1 + u_2 y_2 + \dots + u_n y_n$$

Constraints:

Equation of total input to 1;

$$\sum_{i=1}^m v_i x_i = 1$$

$$v_1 x_1 + v_2 x_2 + \dots + v_m x_m = 1$$

The output is equal to input or less than it, hence ($efficiency = \frac{output}{input} \leq 1$);

$$\sum_{r=1}^n u_r y_r - \sum_{i=1}^m v_i x_i \leq 0$$

$$(u_1 y_1 + u_2 y_2 + \dots + u_n y_n) - (v_1 x_1 + v_2 x_2 + \dots + v_m x_m) \leq 0$$

Non-negativity;

$$u_1, u_2, \dots, u_n \geq 0$$

$$v_1, v_2, \dots, v_m \geq 0$$

Where:

Θ = efficiency,

u = weight of i^{th} output,

y = quantity of i^{th} output,

v = weight of i^{th} input,

x = quantity of i^{th} input.

Above explained DEA model was input-oriented. If the model were output-oriented:

$$\begin{aligned}\sum_{r=1}^n u_r y_r &= 1 \\ -\sum_{r=1}^n u_r y_r + \sum_{i=1}^m v_i x_i &\geq 0 \\ u_1, u_2, \dots, u_n &\geq 0 \\ v_1, v_2, \dots, v_m &\geq 0\end{aligned}$$

And the objective function would be:

$$\min \theta = \sum_{i=1}^m v_i x_i$$

3.3. Port Investment and Finance

As similar to other shipping industry related items like vessels and shipyards, seaport investments are capital intensive. Especially, by the constant growing size of container ships, the container vessel terminal investments are in need of expensive equipment and berth draft capacities which increases the capital cost. For instance, sunk investments; the

breakwaters have life spans measured in centuries and decades for quays and piers. These investments are irrevocable. Hence, the decision-makers should carefully take consideration of forecasted demand from the hinterland and forecasted demand for transshipments.

According to an International Transport Forum (ITF) report (2015), the container terminals which have capacities around 500.000 TEU are characterized as small scale terminals which attract the local rather than the global shipping lines. And the same report indicates that a container terminal with 950 m quay length and 1 million TEU capacity can serve to global operators. In Lloyds list 100 container ports ranking (2019), the first port's 2018 annual throughput was 42 million TEU and the last one's annual throughput for the same year was 1.66 million TEU. These two terminals had 40 and 1.56 million TEU annual throughputs in 2017, respectively. They had 5% and 6% increase rates in just one year. Nevertheless, in its 10 years life, 1 million TEU capacity Ceres-Paragon terminal in Amsterdam port could never exceed the handling of 300.000 TEU and now it has been closed. (ITF, 2015) When these examples are considered the importance of future forecasts for port projects will be understood better.

In addition, the concept of port investment does not cover just the foundation of a completely new port. It includes the improvements of infrastructure and superstructure separately or together and the dredging operations at the port basin or at approach channel of the port. These type of investments are generally called as expansion, extension, rehabilitation, channel/berth dredging/deepening projects.

In spite of huge financial resource requirements, seaports create a wide range of economic impacts both in their hinterland region and at the national level. A newly built port can even have effects outside of its national boundaries with its competition creating potential as a transshipment node in the global transport network. However, the impacts of seaports are not limited by the economy and business opportunities. Port facilities are mainly founded at the point of junction of land and water. Nevertheless, the optimum locations

for ports are the places where weather working days are maximized. And these type of areas are mainly at environmentally sensitive natural harbours, bays or delta fronts where the streams flow into the sea. Besides, many ports are located on the rivers which have inland waterway transport possibilities and they are the connection point among sea routes and inland waterways. Hence, these big sized facilities cause a wide range of environmental changes with their infrastructure both in land and waterside. They can cause loss of seafront space and wetlands, pollution of water and traffic congestion in the region. In this respect, a port investment should not be evaluated by just commercial benefits perspective and its long term effects on ecosystems and habitats should be considered at environmental and social aspects.

Musso, Ferrari, and Benacchio (2006) divided port investments two contrast ways to each other: port as a public service instrument and port as a business system in a highly competitive market. From the private shareholders' (i.e. the entrepreneurs) perspective port is a commercial business investment and their main expectation is based on the direct benefit, mainly the profit. Nevertheless, port creates indirect benefits for the society like employment, source of revenue and taxation. At the same time, ports create business opportunities in the region by their subsidiary industries. Therefore, the port's social and commercial benefits are interbedded with each other.

There are different administration and financing types of ports. The land ownership is generally held by governments except a few countries like the United Kingdom. Mostly, landlord governments lease their infrastructure to private operators for the long term and provide them concessions to invest in the superstructure. It is a public-private partnership (PPP) where generally public authority invests in infrastructure and private sector invests in the superstructure and delivers the services at the port efficiently. Nevertheless, to encourage private involvement to infrastructure construction and to solve the finance matter, governments use BOT method for building new port facilities. This method allows one or a group of (consortium) private entities to bid a port construction project which is

designed by a government. After the construction, the bidders have the right to operate the port for the long term as a concession. End of the period the facility is subject to transfer to the government again. Generally, there are phases of building in the BOT model. The private entity is responsible for the development of port phase by phase and responsible for the investment financially. But, the development size is restricted by the authority which restricts the private entity's appetite for investment. However, the authority has limited control on the port management. Also, the design of the project can be included in the model. Alternatively, equity financing, lending from financial institutions, government or port authority financing issuing primary market bonds, superstructural equipment leasing are other types of port financing.

3.4. Cost-Benefit Analysis (CBA)

In general, there is no single best methodology which presents certain provisions about an investment, policy, decision or project is beneficial or not. There is a tidy amount of evaluation methods for national or international projects and policies in social, economic or environmentally aspects. Cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), input-output analysis (IOA), multi-criteria analysis (MCA), environmental-impact analysis (EIA), strategic-environmental analysis (SEA), resource-management analysis (RMA), rapid assessment methods (RAM), decision analysis (DA), land suitability analysis are some of the methods that are used for assessments.

Ustaoglu and Williams (2019) argue that CBA is the most common evaluation way of both national investment project appraisals and scientific research analysis. They specified the CBA as a conventional tool to assess the potential costs and benefits of a public investment or major transportation projects. In the case of multiple mutually exclusive projects, CBA seeks the maximum benefit returning alternative to society. It is a quantitative, mono-criterion analysis which is based on monetary terms, so, all the costs and benefits are evaluated in this single unit. However, while some costs and benefits can

be exchanged for a price some of the intangible ones cannot be expressed in monetary terms. For example the impact of pollution, time savings, traffic congestion and so on. There are two approaches to mitigate this issue. First one is direct approach that tries to estimate willingness to pay these intangible goods and the second one is indirect approach that tries to measure the relation between the dose (air pollution) and the effect (health problems) (Musso et. al, 2006) Shadow prices are the estimated prices for intangible assets which are not normally sold or purchased in market.

In the business world and public sector, the essential techniques of project evaluation are payback period, net present value (NPV) and internal rate of return (IRR). Estimated cash flows are the most important and difficult step for these techniques. By sensitivity analysis, NPV changes can be observed by a given change in an input variable while others are constant. Hence, the risk of different cash flows can be measured.

3.4.1. Payback Period

The payback period is the time period to recover the cost of the original investment. It is a simple and oldest way to evaluate capital budgeting of investments. The payback period is measured by simply adding up the expected cash flows annually. When the cumulative amount of net cash inflow reached the total initial project cost payback period is terminated. It can be formulated as:

$$\text{Payback} = \text{Years before full recovery of initial investment} + \frac{\text{Uncovered cost at start of year}}{\text{Total cashflow during year}}$$

If the payback period is shorter than maximum cost recovery time, which is indicated by the investor, the project is considered as acceptable. However, this method ignores the time value of money. It just informs about how quick the invested money will be recovered without discussing its decreasing value during the period. Nevertheless, the risk increases in the long term because of the uncertainties in the future. Therefore, a short payback

period presents less risk. Another weakness of the payback period is the cash flows after the completion of the period. Especially, a comparison of more than one project the shorter payback period does not mean the more profitable and beneficial option in every time. Sometimes a longer payback period project can provide higher returns in its total life span. Payback period ignores the cash flows afterwards.

3.4.2. Net Present Value

Firstly, assuming that \$100 is deposited to the bank with 3% after-tax interest. At the end of the initial year, it will be $\$100 \times (1 + 0.03) = \103 . If it continues to stay at the account at the end of the second year the amount will be $\$103 \times (1 + 0.03) = \106.09 which equals to $\$100 \times (1 + 0.03) \times (1 + 0.03) = \$100 \times (1 + 0.03)^2 = \106.09 . Then, if it was deposited for three years, the final amount would be $\$100 \times (1 + 0.03)^3$. If an M amount invested for t years with an i interest rate $M \times (1 + i)^t$ the formula shows the future (t years later) value of M in the present.

Secondly, if it is supposed \$100 is borrowed to pay one year later and the interest rates are 3% and there is zero inflation. The \$100 paid back after one year without any interest or addition is not equal to the \$100 borrowed now. Because if it is deposited to the bank, one year later the bank will pay \$103 back. Hence, because of the 3% interest rate in the market one year later \$100 will be equal to $\$100 \div (1 + 0.03) \cong \97.87 . It is the present value of a future amount of money. It is the maximum money which will be paid to have the right of receiving \$100 after one year. Therefore, a future amount's today's value can be formulated as $M/(1 + i)^t$ where M is an amount of money from the future, i is the interest rate and t is the number of years. Even though the zero inflation, today's \$100 will worth less in the future if the interest rates are positive. In this case, the interest rate will be discount rate and $(1+i)^t$ will be the discount factor. Then, the present value (PV) of annual constant M payments for a t period will be formulated as:

$$PV = M_0 + \frac{M_1}{(1+i)^1} + \frac{M_2}{(1+i)^2} + \dots + \frac{M_t}{(1+i)^t}$$

Although this formula does not contain inflation effect the result will be same if the M constant value is multiplied with f inflation rate as $M \times (1+f)^t$ then, the interest rates would not be stable against inflation and they will be multiplied by the same rate again. Hence, the formula will be the same as above again. However, if there is inflation the M amounts will not be constant and they will vary according to the inflation and also they will be the real amounts at market conditions. Equally, the interest rates will include the inflation effect.

Finally, NPV is a discounted cash flow (DCF) technique which employs time value of money. Simply, it is the sum of the present values of all the cash inflows and outflows. It can be computed as the following equation (Sahoo, 2019):

$$NPV = CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \dots + \frac{CF_n}{(1+k)^n}$$

$$NPV = \sum_{t=0}^n \frac{CF_t}{(1+k)^t}$$

In the formula, CF is the net cash flow and k is the rate of return. The logic behind the rate of return is the same as the discount rate but the first one is indicated by the investor according to its expectation from the project. If this expectation is specified equal to the discount rate the investor would unnecessarily risk its equity on a project while there is a low-risk alternative opportunity is available.

The project is worthy to invest if the NPV is positive and it is unacceptable if the NPV is negative. If there are several alternative projects the higher NPV provider is better than the lower ones. If there are two mutually exclusive alternatives and they both ensure positive NPVs, the higher NPV will be better, too. However, NPV has two drawbacks. It

is in favour of big projects because of the greater numbers result with greater NPVs. And it is so sensitive to the discount rate.

3.4.3. Internal Rate of Return

In order to eliminate the NPV's weak points, the internal rate of return (IRR) method removed the discount rate from the calculation and user-independent IRR has taken its place. Simply, it is the discount rate which makes the PV of a project's net total cash flows equal to the investment outlay. Thus, it is the rate which equals the NPV to zero. Following equation can be used to find a project's IRR (Sahoo, 2019):

$$CF_0 + \frac{CF_1}{(1 + IRR)^1} + \frac{CF_2}{(1 + IRR)^2} + \dots + \frac{CF_n}{(1 + IRR)^n} = 0$$

$$\sum_{t=0}^n \frac{CF_t}{(1 + IRR)^t} = 0$$

In NPV calculation, the discount rate is decided by investor and it is also called as the required rate of return. Generally, it is the minimum rate of return by interest rates in the market. If the project's IRR is higher than the required rate of return that project is acceptable. That means until the IRR value, the project gives a surplus and this will increase the wealth of shareholders. Hence, if the minimum required rate of return (discount rate) is lower than the IRR, there is an extra return space between the IRR and discount rate beyond the expectation of the investor. Conversely, if IRR is lower than the required rate of return then there is a cost for investors.

A study by Petry and Sprow (1993) states that while %60 of companies were using payback period as a primary capital budgeting technique in the 1960s, after 30 years nearly 90% of companies used the NPV and IRR as a primary or secondary decision

methodology. It means that these techniques are preferred because of their value-maximizing structures. When an NPV is \$100, it means that if the project is carried out the investor's wealth will increase \$100 in today's value. When a project's IRR is %10 the project will provide a %10 return on its investment. NPV and IRR always give the same results for a project. If the NPV is positive then IRR will be higher than the discount rate.

The discount rate where the two projects' NPVs are equal to each other is called the crossover rate. Table 4 and Figure 23 shows an example calculation and graph of two imaginary projects. Project L is a long term while S is a short-term one. Project S has a higher IRR (%13) than L (%9.8) but project L's NPVs are exceeding the project L after the intersection point of two lines where the discount rate (~%5.7) and NPV (~\$127) are equal for both projects. In the graph, the project L's NPV line has a steeper slope that means the rate of return has a greater impact on project L. Hence, cash flows are more sensitive to the changes in the rate of return. Project S presents relatively faster cash flows than project L.

Table 4. Project L&S Data Table

Year	Expected After-tax Net CFs (\$)		Discount Rate	NPV-S (\$)	NPV-L (\$)	CF(S)-CF(L)
	Project S	Project L				
0	-1000	-1000	0%	250,00	350,00	0
1	550	50	5%	141,66	152,58	500
2	400	200	10%	49,14	-7,15	200
3	200	450	15%	-30,60	-137,72	-250
4	100	650	20%	-99,92	-245,52	-550
IRR=	13,0%	9,8%	Crossover Rate=			5,7%

(assumed by author)

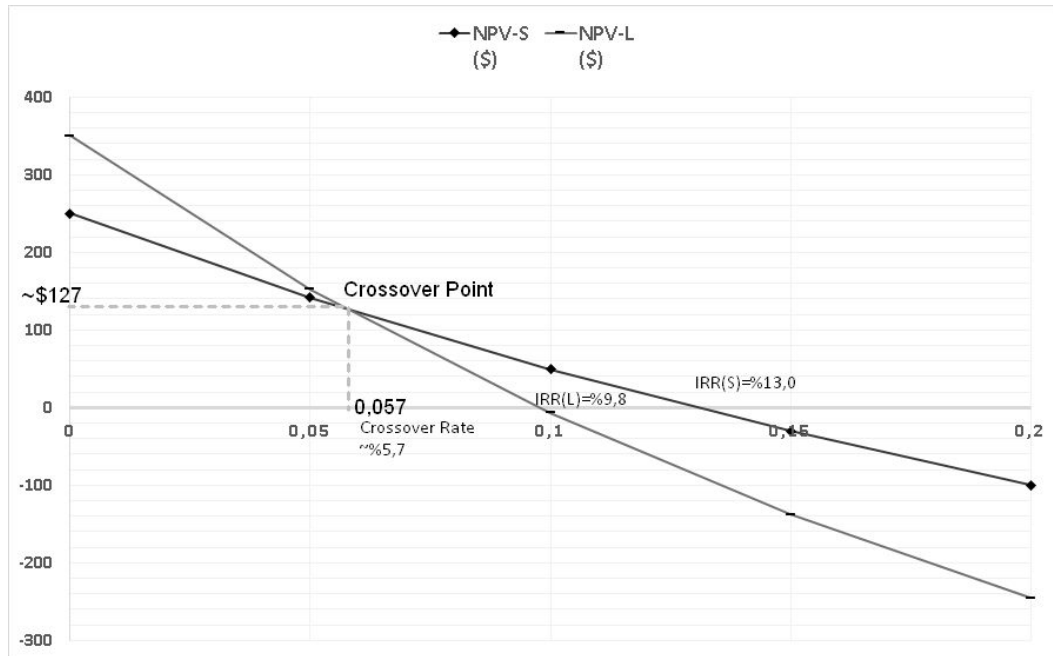


Figure 23. NPV comparison for project L&S

If the projects are mutually exclusive (i.e. we can choose either one or reject both of them) there will be a conflict between project L and S. Below the crossover rate (%5.7) NPV ranks the project L higher but IRR of project S is greater than L. At this point there is a timing difference and/or a scale difference between the projects. In the case, project L and S have equal initial investments and there is no scale difference between them. However, there are timing differences in cash flows. Project S is expected to generate higher cash flows earlier. In spite of its later high cash flows, project L's NPVs are greater in under the crossover rate. If the scale of projects were different the investor would make the decision incompatible with the funding opportunities. But, when the scale is the same, the investor should analyse the future cash flow expectations required for loan payments or new investments. Generally, in the evaluation of mutually exclusive projects, the NPV method will provide better analysis with long term returns (Sahoo, 2019).

3.5. Previous Studies

Roll and Hayuth's study "Port Performance Comparison Applying DEA" (1993) is identified as the first implication of the DEA method to the port industry. (Baysal, Uygur & Toklu, 2004) Hovi analysed Oslo Port development with two alternative solutions by CBA. Martinez-Budria, Diaz-Armas, Navarro-Ibanez, and Ravelo-Mesa compared 26 Spanish ports with DEA in 1999. Tongzon (2001) measured the relative efficiency of four Australian container terminals with twelve other international container terminals using DEA. In her study (2003), Guler analysed the benefits of a dredging operation at an imaginary port by using CBA method. Cullinane, Song, Ji, and Wang (2004) measured 25 container terminals relative efficiency in top 30 world ranking. Barros and Athanassiou (2004) compared the efficiency of 20 ports from Greece and 10 ports from Portugal. Baysal et al. (2005) used the DEA method to measure the efficiency of seven Turkish public ports. In their study, the number of staff and capacity in weight were input; annual throughput and income were outputs. In 2005, Cullinane et al. studied privatization and port efficiency with DEA. Bayar (2005) applied the DEA for port efficiency measurement by using berth length, and crane number as inputs and container throughput as output. Australian government used CBA for Port Phillip Bay Channel Deepening Project. Coto-Millan, Nunez-Sanchez, Pesquera, Inglada, and Castanedo (2010) made a CBA for a new container terminal in Santander Port. In 2013, Mokhtar applied DEA approach to six Malaysian port to measure the technical efficiency of container terminals. Ding, Jo, Wang, and Yeo used DEA to measure the relative efficiency of 21 small and middle-sized container terminals in China. In his research, Guner (2015) analysed a mixture of 13 public and private ports efficiency with a two-staged DEA method. He also had a study in 2014 about passenger port efficiency with DEA. Zheng and Park (2016); Kutin, Nguyen, and Vallee (2017); Lopez-Bermudez, Freire-Seoane, and Gonzalez-Laxe (2019) are the other authors of container terminal efficiency analysis.

CHAPTER FOUR – IMPLICATION OF METHODOLOGY AND FINDINGS

This section is constituted by two main parts. Firstly the efficiency analysis of POI will be made, secondly, the alternative container terminal investment Çandarlı Port project will be compared with Rehabilitation Project of İzmir Bay and Port (POI) in terms of their revenues and profitability.

4.1. Efficiency Analysis

In this part Data Envelopment Analysis (DEA) will be used to examine the 18 container terminals which are in competition with POI or they are placed in the same country.

4.1.1. Selection of Input and Output Variables

Cullinane et al. (2004) stated that a port can increase its productivity by using the latest developed, expensive equipment if the aim is only maximizing the cargo throughput. But, if the goal is profit maximization, allocative (price) efficiency should be observed in decisions. In this study, inputs or outputs in value like profit, expense, income will not be used because of the data unavailability. Hence, the efficiency measurement will be based on relative technical efficiency and scale efficiency. Thus, the infrastructure and superstructure technical capacities will be the inputs and the annual throughput of

container terminals will be the output. Therefore, the study will compare the ports in terms of capacity utilization.

Herein, a question arises. Is the demand equal for all decision-making units (DMU)? It can be supposed, the low demand for a DMU can lead to errors with these variables at this measurement. Because, a low demand will result in low throughput, but the technical capacities will be stable and efficiency will decline. Nonetheless, it should be considered that low demand will be also valid for the other DMUs in the analysis. In a globalized world, it is inevitable to be isolated from the external socio-economic, political or geographical changes. Besides, regional or national level circumstances can differentiate the case in favour of the DMUs which are outside the impact area of the negativity. So, the DMUs in the orbit may seem inefficient relative to the other DMUs. Hence, DEA puts emphasis on the selection of DMUs and their similarity in some aspects.

Due to some private ports' apathy of replying data requests, they were mainly obtained from secondary resources like market reports, old studies, web sites, strategy plans. However, they were checked from different resources for ensuring relevance and validity. Due to lack of data for 2018, analysis has been made for 2017.

4.1.1.1. Berth Length

There is no typical length dimension for container vessels. At the beginning of the 2000s, a 6600 TEU Maersk S-Class container ship (Figure 24) was a giant in the liner shipping industry and they were serving among hub ports. Nowadays, they are just middle-sized vessels. And now, 20.000 TEU capacity mega box ships are in service for the hub to hub transport. Just 20 years ago, while a container ship, which is more than 250 m in length, was considered to be long, today's mega carriers are around 400 meters. Hence, container terminals' berth length is an important input criterion for cargo handling capacities.

Without adequate berthing space, other capabilities of the terminal will be unemployed. Therefore, berth length has been chosen as an input.

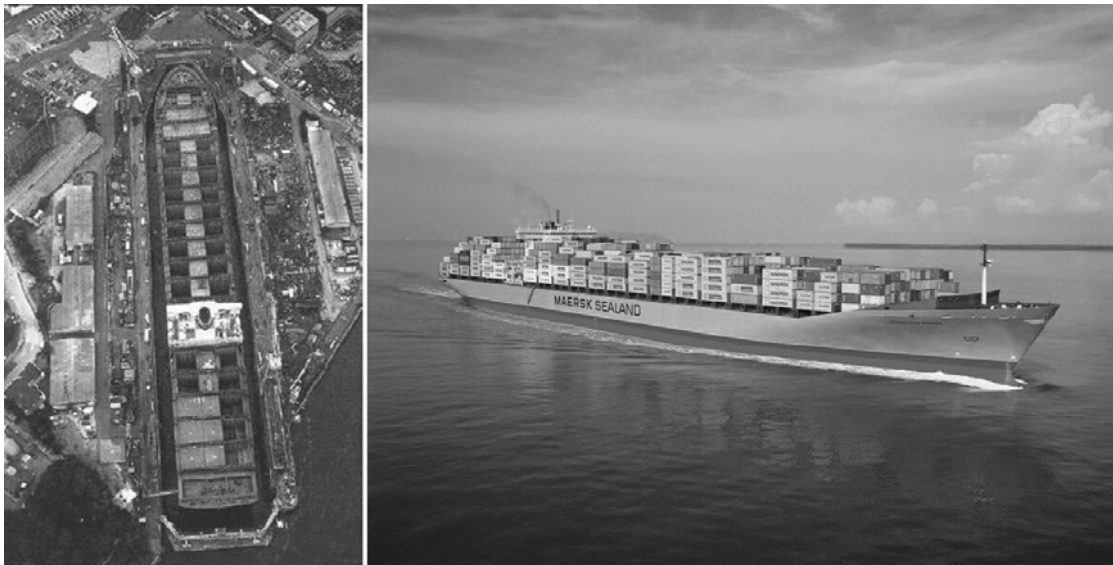


Figure 24. Maersk S-Class vessel in the shipyard and in-service

4.1.1.2. Depth at Berth

Although it is an easily obtainable data, during the literature view it has been noticed many DEA studies did not use the depth availability of berths as an input. However, while 6.600 TEU Maersk S-Class container ships has 14,5 m maximum draught when they were the largest ones at the beginning of the 2000s, today's 23.756 TEU gigantic container ship "MSC GÜLSÜN" has a maximum 26 m draught. (MSC, 2019) The increase in maximum draught is more than 10 meters in approximately 20 years. If a container terminal cannot be called by big sized vessels which have more than 12 m draught like Panamax and post Panamax ships, the cargo is carried with smaller feeder vessels after it is transhipped at other proper ports. Hence, the transportation cost increases and port efficiency declines because of the many repetitions of berthing, mooring, and preparation for handling

operations with plenty of feeder vessels. However, the bigger sized vessels decrease the number of calls but increase the time on loading and discharging of cargoes.

Depending on the same reason, the number of vessel calls is not used as an input because of their unclear contribution to efficiency. It can be thought instead of the number, the TEU capacity of vessels may be evaluated as an input. But, a vessel does not load or discharge its whole carrying capacity at a single terminal. Container ships call multiple ports in their scheduled routes. So, vessel number or capacity will exactly lead error in measurement.

On the other hand, when the maximum draught of “MSC GÜLSÜN” is considered, berth depths that exceed 26 m will be ignored because of their dis-contribution to the services and they will be handled as equal to 26 m. At this point, the question of a higher draught vessel with less TEU capacity can come into minds. But in spite of its 26 m maximum draught at maximum mass is loaded, its cargo mainly includes valuable but light goods like electronics, textiles, food and etc. Hence, it is really an exceptional case for a container ship to reach its maximum draught. In conclusion, maximum depth restricted with 26 m will be used as input.

4.1.1.3. Number of Quay Cranes

Quay cranes serve directly to handling operations ship to shore or vice versa. Their speed and effectiveness are very influential in the general efficiency of container terminals. So, they will be separately evaluated as input from the yard cranes. But, also MHCs and ship-to-shore/shore-to-ship gantry cranes (STS) will be used separate inputs because of their different characteristics of speed and movements.

Additionally, quay cranes will not be taken into consideration with their loading-discharging capacities. Nowadays, technically, maximum tons of cargo loading availability or permission for a high cube 40 feet container is around 32 tons. Hence, it

will be unnecessary to evaluate the quay cranes, which generally have higher handling capacities than 40 tons. Because, their service is mainly related to units, not weights.

4.1.1.4. Container Stockyard Area

Stockyard area contribution to the efficiency of the container terminal is a complex issue. Straddle carriers and RTG cranes are commonly used in container terminals for stockyard operations. When it is considered straddle carriers can stack the boxes maximum 3 tiers while the RTG cranes can stack them between 4 and 8 tiers, stockyard area utilization will be very dependent on the type of equipment. (Büyükozer, 2006) Nevertheless, the proper choice of equipment is also an obligation of the terminal. The management should use the proper equipment according to the cost and physical requirement.

4.1.1.5. Annual Container Throughput

Annual container throughput is a technical indicator of what was done at a container terminal for a year. It is the pure output of produced work. A 20 feet container loading from shore to ship means the same in all ports around the world and it is called as one TEU. Nevertheless, if the revenue side is addressed as an output, it should be the measurement of allocative efficiency. Likewise, throughput in weight will not be used as an output. It is an essential criterion for bulk shipping but it is more meaningful the box (unit) scale in the container shipping industry.

4.1.2. Selection of DMUs

Firstly, DMUs are chosen according to the location criteria. They are the container terminals; which serve the same hinterland with POI or which are in the boundaries of the same country (Turkey) or which are the competitors of POI or which serve in East Mediterranean Sea. A scale criterion is not observed among them because constant returns

to scale (CRS) DEA (also called CCR method) measures the efficiency independent from the scale. The DEA analysis comprises 18 DMUs which includes POI. 17 container terminals were put into code as DMU1, DMU2, DMU3 and so on.

4.1.3. Data Issues

The input and output data of DMUs is shown in Table 5.

Table 5. Input and Output Data of DMUs

(2017)	INPUTS					OUTPUT
DMUs	Berth Length (m)	Max Depth at Berth (m)	No. Of Quay Gantry Cranes	No. Of MHCs	Stockyard Area (m ²)	Container Throughtput (teu)
DMU ₁ -POI	1400	10	5	7	250 000	639 000
DMU ₂	705	26	2	2	240 000	281 182
DMU ₃	840	17,5	2	5	160 000	310 548
DMU ₄	700	16	3	0	420 000	200 880
DMU ₅	1485	15,8	12	5	485 900	1 592 000
DMU ₆	1605	16,5	10	5	422 485	1 709 047
DMU ₇	2024	16,5	7	6	370 484	1 046 135
DMU ₈	2010	18	14	2	400 000	936 407
DMU ₉	680	19	0	4	128 284	184 923
DMU ₁₀	450	14,5	3	0	120 000	241 423
DMU ₁₁	922	15,5	6	0	430 000	434 812
DMU ₁₂	841	16	4	5	210 000	485 539
DMU ₁₃	920	15,5	4	2	400 000	737 837
DMU ₁₄	775	26	8	0	200 000	495 499
DMU ₁₅	945	12	4	1	181 750	85 508
DMU ₁₆	1823	15,5	14	0	500 000	1 525 000
DMU ₁₇	1200	16,5	21	0	600 000	2 968 308
DMU ₁₈	3300	19,5	35	1	700 000	4 145 264

(compiled from various sources)

When the descriptive statistics of inputs and outputs in Table 6 are checked, it can be seen that the standard deviation is high. As a non-parametric method, DEA requires homogeneity in DMUs but it does not stipulate a normal distribution of variables. On the other hand, a study by Sarkis (2007) shows that subtraction of perfect correlated (correlation coefficient is equal to 1) inputs from the DEA did not make a significant change in efficiency scores. Besides, as shown in Table 7. perfect correlation does not exist in study.

Table 6. Descriptive Statistics of Variables

	<i>Throughput</i>	<i>BerthLength</i>	<i>MaxDepth</i>	<i>QuayCranes</i>	<i>MHCs</i>	<i>Stockyard</i>
Mean	1 001 072,89	1 256,94	17,02	8,56	2,50	345 494,61
Median	567 249,50	933,50	16,25	5,50	2,00	385 242,00
Mode	#N/A	#N/A	16,50	4,00	0,00	400 000,00
Maximum	4 145 264,00	3 300,00	26,00	35,00	7,00	700 000,00
Minimum	85 508,00	450,00	10,00	0,00	0,00	120 000,00
Std. Dev.	1 075 018,77	700,75	3,95	8,51	2,46	167 725,82
Skewness	1,75	1,45	0,96	1,85	0,40	0,37
Kurtosis	5,40	4,93	4,16	6,25	1,66	2,27

Table 7. Correlation of Variables

	<i>Throughput</i>	<i>BerthLength</i>	<i>MaxDepth</i>	<i>QuayCranes</i>	<i>MHCs</i>	<i>Stockyard</i>
Throughput	1					
BerthLength	0,793384011	1				
MaxDepth	0,048610193	-0,040464871	1			
QuayCranes	0,955908533	0,837284624	0,089352271	1		
MHCs	-0,109894305	0,118677535	-0,250436344	-0,250405808	1	
Stockyard	0,844965813	0,71811774	-0,046253433	0,830385249	-0,243885067	1

4.1.4. Findings

At this stage of study input and output-oriented CRS-CCR DEA implied on variables by DEAP Ver. 2.1(© copyright Tim Coelli) software with Win4DEAP Ver. 1.1.4 (© copyright Michel Deslignerres) windows interface. The efficiency and ranking scores are as shown in Table 8.

Table 8. Results of DEA

	<i>Output Oriented CRS (CCR)</i>	<i>Ranking</i>	<i>Input Oriented CRS (CCR)</i>	<i>Ranking</i>
DMU ₁ -POI	0.733	5	0.733	5
DMU ₂	0.677	7	0.677	7
DMU ₃	0.689	6	0.689	6
DMU ₄	0.489	12	0.489	12
DMU ₅	0.832	3	0.832	3
DMU ₆	1.000	1	1.000	1
DMU ₇	0.841	2	0.841	2
DMU ₈	0.473	13	0.473	13
DMU ₉	1.000	1	1.000	1
DMU ₁₀	0.569	9	0.569	9
DMU ₁₁	0.513	10	0.513	10
DMU ₁₂	0.658	8	0.658	8
DMU ₁₃	1.000	1	1.000	1
DMU ₁₄	0.501	11	0.501	11
DMU ₁₅	0.135	14	0.135	14
DMU ₁₆	0.771	4	0.771	4
DMU ₁₇	1.000	1	1.000	1
DMU ₁₈	1.000	1	1.000	1

The analysis determined 5 container terminals as efficient ones and scored them 1. POI is placed at 5th rank. However, because of the indication of 5 terminals at 1st place, POI's real ranking at 9th place among 18 ports. Nevertheless, it has an efficiency rate of 0.733. When it is taken into account, DMU₁, DMU₁₃, and DMU₁₇ are the main competitors of

POI, it has a higher technical efficiency than all the three terminals. DMU₁, DMU₂, DMU₃, and DMU₁₈ are container terminals which are at Lloyd's List One Hundred Ports. They are MIP PSA, MARPORT, Port Said East and Piraeus terminals, respectively. DMU₁₆ is Ashood Port with an efficiency rate of 0.771 and it is ranked just before POI although its 1.5 million TEU annual throughput.

According to the output-oriented CRS (CCR)-DEA, POI needs a 36% increase for its annual throughput to be one of the efficient DMU in comparison. And it should have at least 871 thousand TEU annual handling output with its current infrastructure and superstructure capacities. (Table 9)

Table 9. Summary of Output Targets

	<i>Output</i>	<i>Target Output</i>	<i>Required Increase</i>
<i>DMU₁-POI</i>	639 000	871 556	36%
<i>DMU₂</i>	281 182	415 149	48%
<i>DMU₃</i>	310 548	450 648	45%
<i>DMU₄</i>	200 880	424 044	111%
<i>DMU₅</i>	1 592 000	1 914 065	20%
<i>DMU₆</i>	1 709 047	1 709 047	0%
<i>DMU₇</i>	1 046 135	1 244 510	19%
<i>DMU₈</i>	936 407	1 978 872	111%
<i>DMU₉</i>	184 923	184 923	0%
<i>DMU₁₀</i>	241 423	424 044	76%
<i>DMU₁₁</i>	434 812	848 088	95%
<i>DMU₁₂</i>	485 539	737 736	52%
<i>DMU₁₃</i>	737 837	737 837	0%
<i>DMU₁₄</i>	495 499	989 436	100%
<i>DMU₁₅</i>	85 508	633 919	641%
<i>DMU₁₆</i>	1 525 000	1 978 872	30%
<i>DMU₁₇</i>	2 968 308	2 968 308	0%
<i>DMU₁₈</i>	4 145 264	4 145 264	0%

On the other hand, POI had handled 898 and 884 thousand TEU in 2007 and 2008 respectively. Besides, its throughput was also above 800 thousand TEU in 2004, 2006 and 2009. Considering the number of MHCs was 3 in those times, POI was doing quite well in the past. Oral (2016) states that a maximum theoretical capacity of a port is like a maximum speed of a car and a car can reach its maximum speed when the road, wind and some other internal and external conditions are proper. A car cannot cruise at maximum speed for a long time. Similarly, he argues that a port cannot maintain its maximum efficiency for a long time and in general they operate at 75% of their maximum capacities.

POI has annual 1.165 million TEU theoretical capacity in last TCDD reports. 75% of its maximum capacity is about 873 thousand TEU. Hence, in compliance with Oral's approach, the CRS-DEA determined a target output 871 thousand TEU for the efficient operation of POI. Although it has a better position at relative efficiency analysis than its main three competitors, the increasing throughput of competitors and declining output of POI should not be ignored in long term decisions.

Nevertheless, DEA evaluates the berth depth as other inputs and it cannot notice its restricting nature for other inputs. If a container terminal loses its position on routes of major shipping lines or the ships with high draft cannot call that terminal, its cargo demand decreases. It may not utilize its infrastructure and superstructure potential. Therefore, the throughput and dependently technical efficiency declines. DEA cannot identify the restrictive effect of this kind of inputs. On the other hand, draught cannot be an absolute cause of the inefficiency. The big ships and feeders serve to maritime transportation together in harmony. They are supplementary to each other. Every port should not have to have high berth depths. Because of the different levels of demand, the small vessels always have a place in maritime transportation.

Another point about the result of DEA is lower efficiencies of new equipped and deep berthed private competitor container terminals. All three main competitors of POI, Ege Gübre, Nemport, and Socar terminals have efficiency scores worse than POI. If the result

is examined with a complete quantitative perspective it can be misleading for decision-makers. Annual cargo throughput is not an absolute result of the terminal's input compound. Cargo volume is also an input for the port system. If a port is not fed by enough cargo, it cannot utilize its technical efficiency. Hence, if there is a surplus of port supply for the hinterland demand, then the cargo volumes will decrease. If the transshipment demand is also low, then the port throughputs will be low, too.

4.2. Investment Appraisal of İzmir Bay and Port Rehabilitation Project

As before mentioned İzmir Bay and Port Rehabilitation Project has two main parts. One of them is dredging a circulation channel and the second one is the expansion of port area by reclamation and dredging of the approach channel and port basin with infrastructure investment. North circulation channel is required for natural life protection in the bay, hence it is not a subject for this study. Approach channel, port basin dredging and other port investments will be evaluated in the upcoming subtitles in business cost-benefit profitability perspective.

4.2.1. Direct Investment Cost Prognosis

The total rehabilitation project was quoted 800 million TRY at 2016 dated environmental impact assessment report. The same report specifies the required investment cost for POI 270 million USD. 300 million USD is mostly mentioned in the press but a development agency report states a 650 million USD investment required for container and passenger terminals. Nevertheless, former president of İzmir Chamber of Trades stated a 50 million USD investment is required for an 11 km length and 200 wide -14 dept approach channel for POI at his speech to the press. (YARIN, 2016) In consideration of 1.8 million m³ dredging for approach channel is only a small part of 35 million m³ total dredging, then the whole operation will approach the 970 million USD with a simple benchmarking. New

work dredging with hopper or non-hopper costs between 9.87 USD and 23.60 USD per cubic yard. (USACE, 2017) It is equal to 12.91 USD and 30.87 USD per cubic meter respectively. When these numbers applied to the rehabilitation project, the total dredging cost will be between 452 million USD and 1.08 billion USD. USACE states 5.8 USD per cubic yard for government non-hopper dredging. When the calculation is made with this bottom price level, total dredging cost will be 266 million USD. Besides, these costs do not include infrastructure investment. If the circulation channel dredging is extracted, the total port-related dredging will be around 10 million m³. According to the aforementioned amounts, the cost will vary between 76 million USD and 309 million USD. On the other hand, USACE's minimum cost is calculated for non-hopper governmental operation. In POI's rehabilitation project hoppers will be used to carry disposal material. The hopper operated option will be at least 93 million USD. Nevertheless, according to the environmental impact assessment report dredging material is comprises of clay and sand. Guler states that (2003) these materials have the lowest dredging cost.

On the other hand, the rehabilitation project contains construction of a new terminal wharf by partly land reclamation, a wharf expansion, and two passenger ship piers construction. A study by The Institute of Trade and Transportation Studies (ITTS) (2000) indicates a 40 acre (160,000 m²) container terminal infrastructure costs around 32 million USD. Land reclamation and cranes are not included in this calculation and there is not any berth depth or wharf loading or mooring capacity information at the study. Rehabilitation project includes a 350,000 m² land reclamation and 550,000 m² container terminal construction. Thus, according to the ITTS study, only the second terminal construction without landfilling costs 110 million USD. Furthermore, the project contains two passenger terminal pier construction and expansion of the current container terminal.

4.2.2. Demand

In recent years, containerization is developing faster than the world average in Turkey. As shown in Figure 25. After 2003 in 15 years, Turkish ports' total container throughput increased 248% though the world total container trade increase rate was around 109%. When considered Turkey changed its import substituted industrialization and opened its market to the international trade in the 1980s, this late faster development is more comprehensible. Changing nature of cargoes, port privatization and fast increase in export has triggered faster development of containerization. Especially, after 2016 the increase ratio is sharper in Turkey.

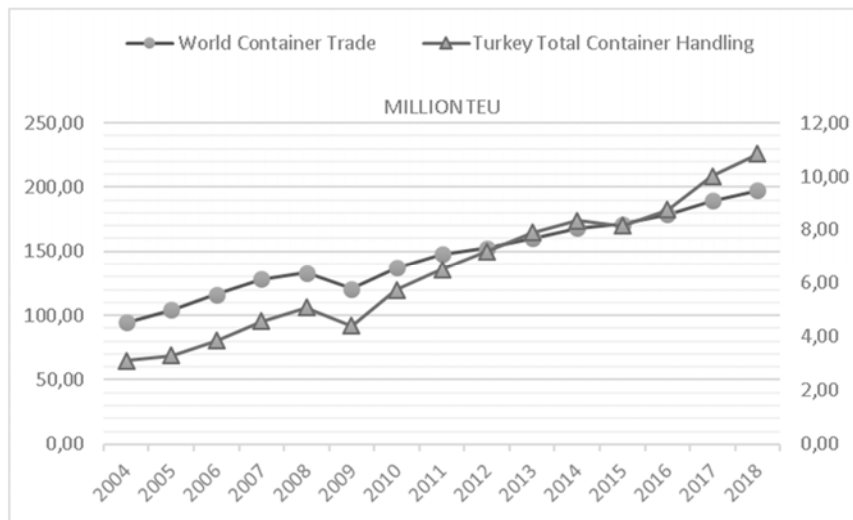


Figure 25. World and Turkey Container Transport

(compiled from UAB & Clarkson)

When the POI's main hinterland Aegean region's container throughput is compared with Turkey's total (Figure 26), it is slower than Turkey's general change with a 179% versus 248% increase in 15 years.

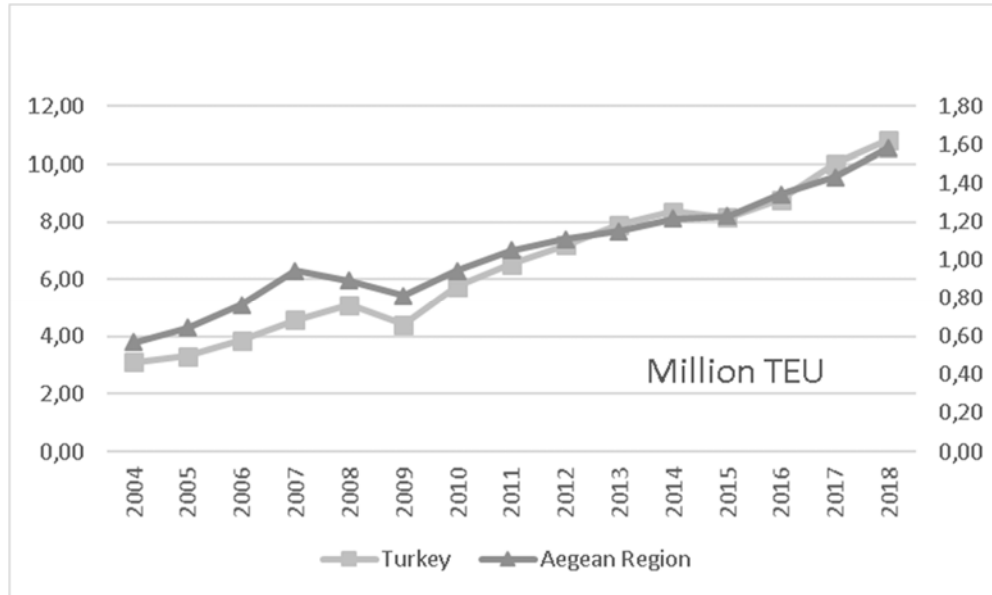


Figure 26. Aegean Region and Turkey Annual Throughputs
(compiled from UAB data)

The population is one of the important factors that affect trade need by changing production and consumption. Hence, maritime transportation and port demand are indirectly effected by population changes. Besides, a population increase by migration can be a result of industrial development, thus the raising job possibilities attract the settlers of other regions. When considered the main hinterland of POI population, İzmir has a higher speed than the region. As shown in Table 10 region's increase 3% slower than the İzmir's.

Table 10. Main Hinterland Population Changes

<i>Years</i>	<i>Izmir</i>	<i>Aegean Region (Izmir included)</i>	<i>Aegean Region (Izmir excluded)</i>
2007	3,7	9,3	5,6
2008	3,8	9,4	5,6
2009	3,9	9,5	5,6
2010	3,9	9,7	5,7
2011	4,0	9,7	5,7
2012	4,0	9,8	5,8
2013	4,1	9,9	5,8
2014	4,1	10,0	5,9
2015	4,2	10,1	6,0
2016	4,2	10,3	6,0
2017	4,3	10,4	6,1
2018	4,3	10,5	6,2
<i>Increase (2007-2018)</i>	<i>16%</i>	<i>13%</i>	<i>11%</i>

(compiled from TurkStat data, in million)

From 2008 to the end of 2018, a total of 1.31 million people migrated to İzmir just in 11 years. When considered its population has already increased 1.6 million in this period and it was 4.3 million at the end of 2018, it can be clearly understood that the city is an attraction centre and the fast population increase was caused mainly by migration. (Figure 27) GDP change helps to explain the population increase. Between 2004 and 2017, in 14 years İzmir's GDP increased 407% while the region's was 399%. (Figure 28) Nonetheless, the GDP ratio between the city and region was always between 2.03 and 2.07 in the period.

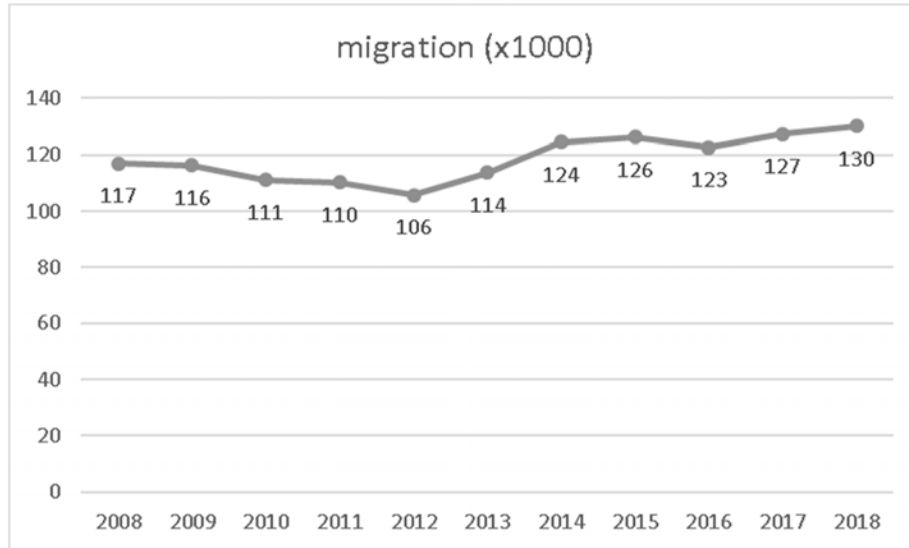


Figure 27. Migration to İzmir
(compiled from TurkStat data)

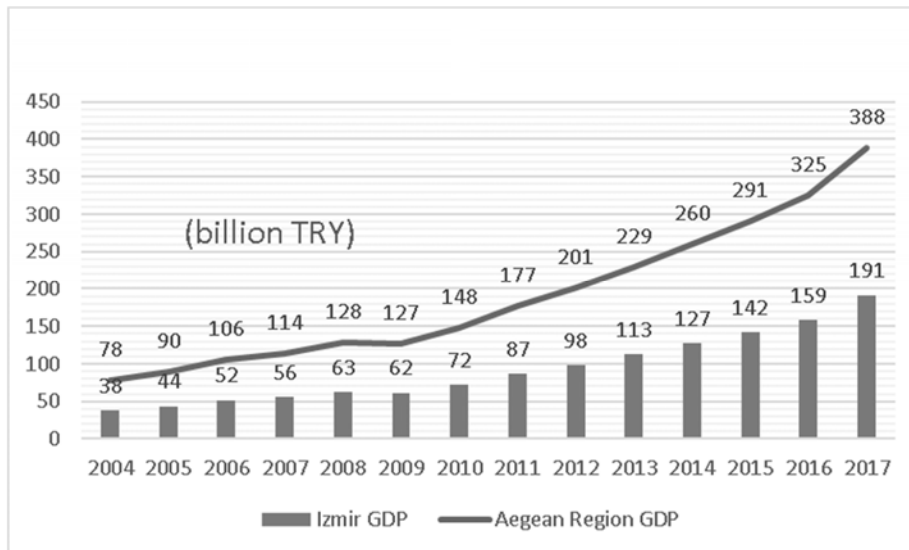


Figure 28. GDP Change of İzmir
(compiled from TurkStat data)

4.2.3. Future Container Freight Demand

GDP, population, employment rates, industrial production volumes, income levels, transportation and trade volumes (export-import) are well known socio-economic variables to estimate future freight demand. Generally, the forecasts are made for a time period between 20-30 years. Hence, in this study, the forecasting period will be 25 years until 2050. The period until 2025 is for completion of investments. On the other hand, transshipment container freight demand estimation should use macro socio-economic variables like world GDP, population or trade volumes. When considered, Çandarlı Port is projected as a hub port, transit freight estimations should be done separately as a macro projection.

4.2.3.1. Micro Projection

To understand the foremost significant factors which trigger the container terminal throughput in Turkey a regression was run by using container throughput as dependent variable and population, industrial production index, GDP, foreign trade volume socio-economic factors as independent variables between 2005-2018 with monthly 168 observations. All data returned natural logarithm for responding skewness because of the large value of variables. EViews© 10 is used for analysis. After the implementation of unit root tests, all the variables were stationary at first difference. (Table 11) The descriptive statistics are given in Table 12.

Table 11. Unit Root Tests

	ADF		PP		KPSS	
	<i>Level</i>	<i>1st Diff</i>	<i>Level</i>	<i>1st Diff</i>	<i>Level</i>	<i>1st Diff</i>
THROUGHPUT	0.4310	0.0000	0.6529	0.0000	-	-
POPULATION	0.6571	0.1032	0.0743	0.0001	1.561575	0.131412
IND_PROD	0.9701	0.2324	0.9872	0.0000	0.154650	-
GDP	0.1785	0.0000	0.1779	0.0000	-	-
FOR_TRADE	0.0501	0.0000	0.0146	0.0000	1.127571	0.237392

Table 12. Descriptive Statistics of Variables

	<i>OBS</i>	<i>Mean</i>	<i>Median</i>	<i>Max</i>	<i>Min</i>	<i>Std. Dev.</i>	<i>Skew</i>	<i>Kurt</i>
<i>THROUGHPUT</i>	167	0.007789	0.008150	0.216378	-0.189099	0.072913	0.076365	2.889104
<i>POPULATION</i>	167	0.000966	0.000000	0.015883	0.000000	0.003439	3.394773	12.80111
<i>IND_PROD</i>	167	0.005112	0.002437	0.216172	-0.288571	0.095481	-0.401448	3.262637
<i>GDP</i>	167	0.002541	0.000000	0.201423	-0.170315	0.030963	2.043509	26.43612
<i>FOR_TRADE</i>	167	0.005452	0.012449	0.217245	-0.354535	0.103412	-0.526756	3.610704

As shown in Table 13 industrial production index and foreign trade volume independent variables are correlated after the correlation test at 0.80 significance level. At this point, the industrial production index variable was eliminated because of the foreign trade's direct effect on transportation demand. Industrial production is also related to the internal consumption of the country and every manufactured good is not subject to export. Nevertheless, both export and import are included in foreign trade volume.

Table 13. Correlation of Variables

	<i>THROUGHPUT</i>	<i>POPULATION</i>	<i>IND_PROD</i>	<i>GDP</i>	<i>FOR_TRADE</i>
<i>THROUGHPUT</i>	1				
<i>POPULATION</i>	-0,249331849	1			
<i>IND_PROD</i>	0,614100881	-0,512829469	1		
<i>GDP</i>	-0,032988055	0,171931178	-0,165162797	1	
<i>FOR_TRADE</i>	0,487562125	-0,438443013	0,868583845	-0,200163002	1

Afterwards, the equation was run on EViews© 10 by least squares method where two of three independent variables were insignificant at %5 significance level. Although F-test and T-test implications with different combinations, they did not turn to be significant. Hence, they were dropped from the equation. At cointegration test dependent and independent variables cointegrated. Therefore, the residuals at 1 lagged level added to the

equation as an error correction term. Then, the ARMA process implied and insignificant ones were dropped again. Following the ARMA process, to ensure the normal distribution of residuals two dummy variables added to the equation. The Newey-West correction was performed on the equation because it was homoscedastic and it had a serial correlation. Finally, there is no non-linearity at the model and it has a 0.537171 R² value that means %53,7171 of data fits the regression. Final equation of data is as shown in Table 14.

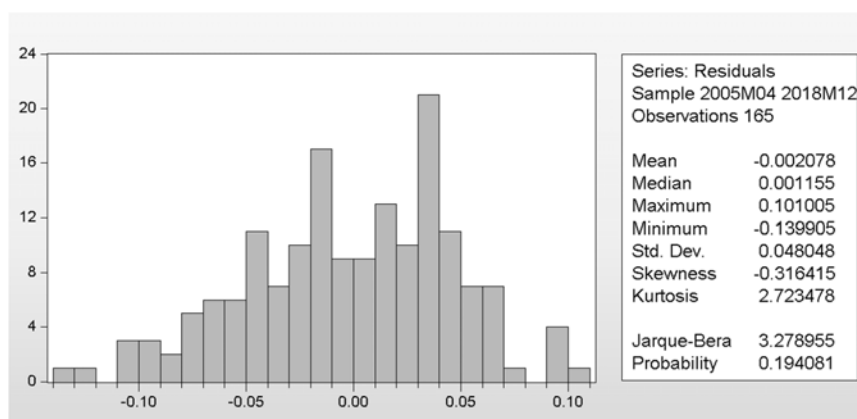


Figure 29. Normality test histogram

Table 14. Final Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FOREIGN_TRADE_VOLUME__USD_	0.398435	0.022319	17.85217	0.0000
RESID01(-1)	0.587903	0.072201	8.142649	0.0000
C	0.005695	0.000111	51.37410	0.0000
DUMMY	0.156027	0.015132	10.31079	0.0000
DUMMY01	-0.161246	0.014615	-11.03256	0.0000
AR(1)	-0.330378	0.073680	-4.483932	0.0000
MA(1)	-0.984892	0.011106	-88.68221	0.0000
R-squared	0.537171	Mean dependent var		0.007369
Adjusted R-squared	0.519595	S.D. dependent var		0.070692
S.E. of regression	0.048998	Akaike info criterion		-3.152583
Sum squared resid	0.379325	Schwarz criterion		-3.020816
Log likelihood	267.0881	Hannan-Quinn criter.		-3.099094
F-statistic	30.56313	Durbin-Watson stat		2.050113
Prob(F-statistic)	0.000000			

In general, GDP and population data are published annually. Annual data was used by repeating method in the regression. Hence, their insignificance was tested with an annual data regression again. Population variable was insignificant but GDP was significant. However, the model was non-linear, so it cannot be used for analysis. Besides, in Granger causality test industrial production index and GDP did not have causative relation with container throughput.

After indicating the significant and causative socio-economic factor of container throughput, three forecast scenarios of it was calculated in Excel by trendline. (Figure X.) Annual foreign trade volume will reach 1 billion USD, 765 million USD or 517 million USD in 2050 according to the best, normal or worst scenarios respectively in a 95% confidence level.

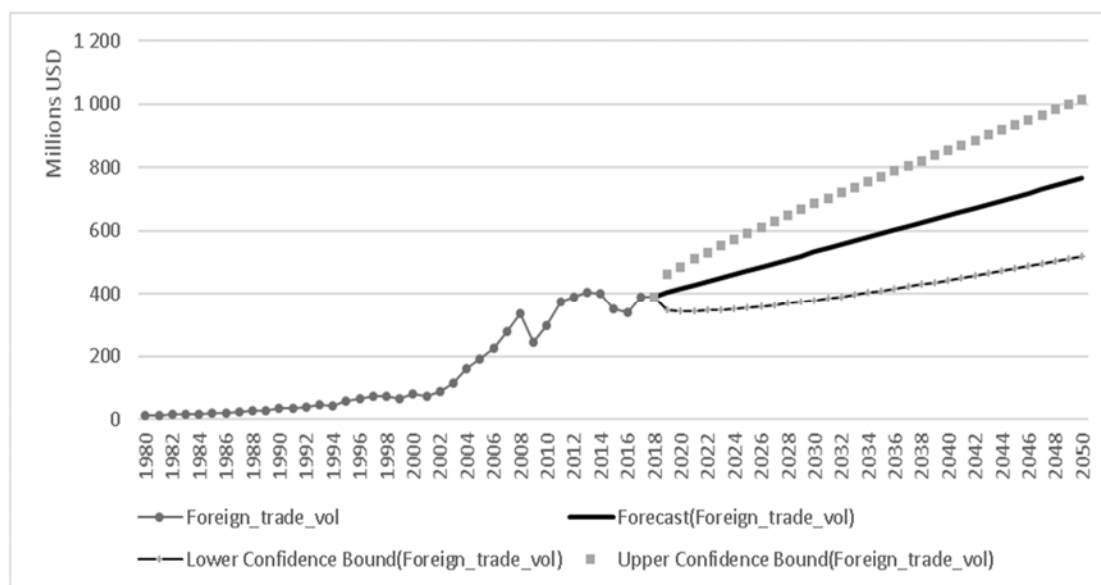


Figure 30. Turkey's foreign trade forecast until 2050

In consequence of these scenarios, to make cargo assumptions, this time a least square regression with annual data was run for the last 15 years Turkey's foreign trade volume

and Aegean Region container port throughput. This regression aimed to provide a mathematical basis for cargo forecast assumptions. The equation with 0.732999 R² was obtained as follows:

$$\begin{aligned} & \text{Aegean Region Annual Port Throughput (TEU)} \\ &= 0.00304974738883 \times \text{Annual Foreign Trade Volume (USD)} \\ &+ 75536.0125144 \end{aligned}$$

However, because of the slowdowns in Turkey's foreign trade volume after 2008 and 2013, the forecast based on the aforementioned equation estimates low outputs as shown in Figure 31. The forecasted throughput for 2025 is approximately equal to the throughput in 2018.

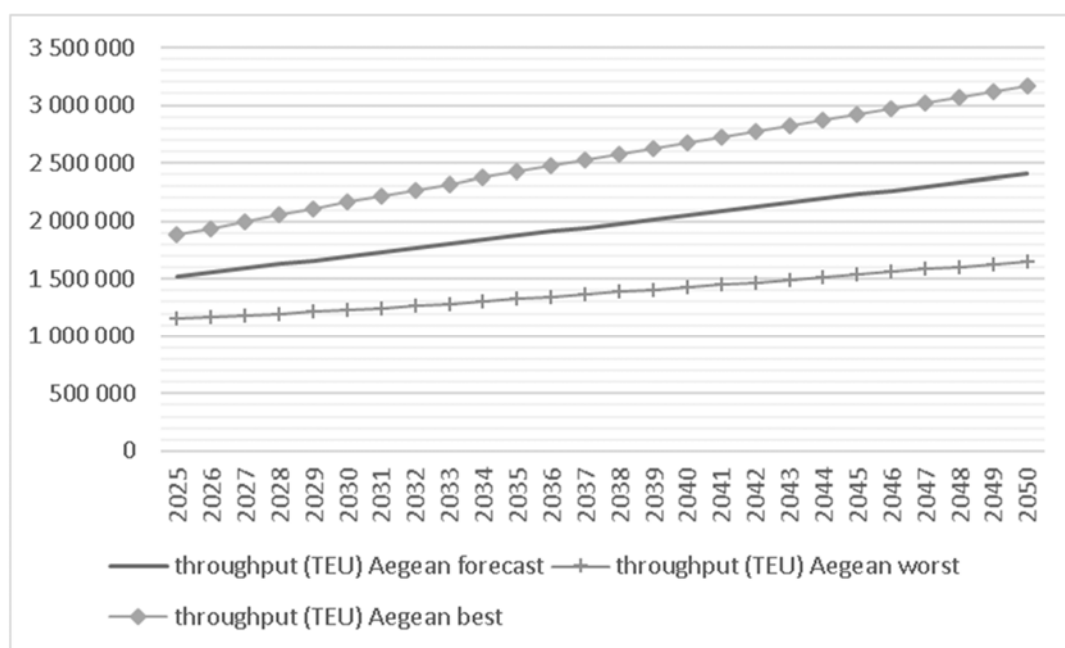


Figure 31. Total container throughput with regression

Therefore, when the estimation is calculated by the region's throughput trendline since 2009 with a 95% confidence level the result will be as shown in Figure 32.

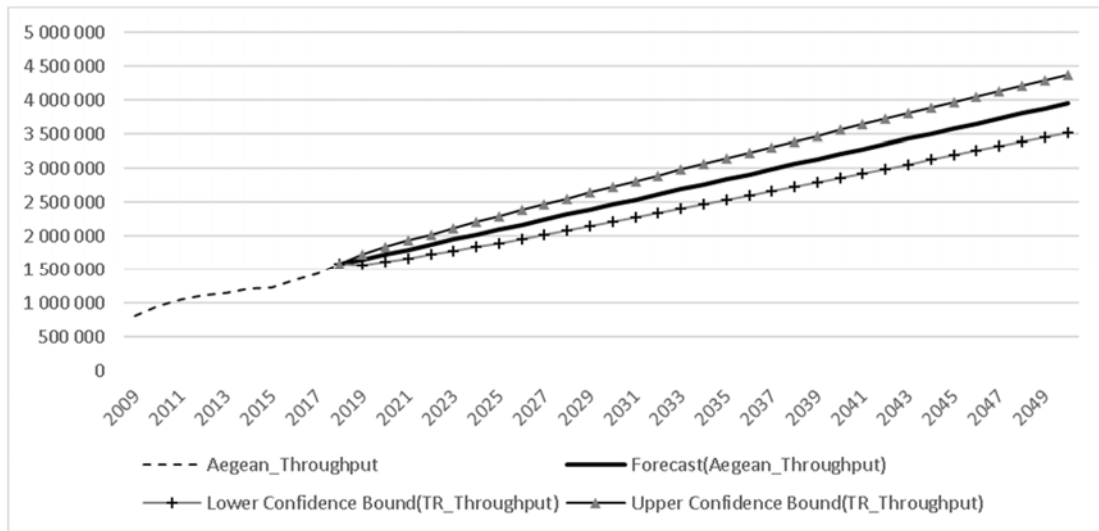


Figure 32. Aegean Region container throughput forecast by trendline analysis

In conclusion, according to Turkey's foreign trade relevant forecast scenarios, in 2050 Aegean region will have 3,2 - 4,4 million TEU potential throughput in best cases while the average scenario forecasts are between 2.4 and 3.9 million TEUs. And the worst scenarios are between 1.6 and 3.5 million TEUs. To ensure the including all the possibilities the highest and lowest valued curves will be evaluated as upper and lower frontiers, thus the best case will be 4,4 million TEU the worst case will be 1,6 million TEU demand in 2050. On the other hand, the population was insignificant on national container throughput. However, when considered the local high population increase in İzmir it may be a triggering effect on hinterland's output. Nonetheless, using just regional data can cause abstraction of the region from the general socio-economic factors of the country. A city or a part of a country cannot be evaluated separately from the general

dynamics of a nation. For instance, a change in exchange and/or interest rates or financial crises will be effective in the whole country.

4.2.3.2. Estimation of Transshipment Cargo

Currently, the transshipment container number is as low as it can be ignored at Aegean container terminals in Turkey. In 2018, only 370 of 1.55 million TEU port throughput was transit box. It was 3,972 of 1.432 million TEU in 2017. (UAB, 2019) Hence, every extra transit container is a plus for the region's throughput.

İzmir ports are on the way of Black Sea shipping routes and they also can serve to the north and south Aegean corridor. When the location of 4 Turkish Aegean container terminals across the Mediterranean second-ranking container terminal with 4.9 million TEU throughput considered, a great potential is hidden at this topic. According to the Lloyds List data, Piraeus Port has grown %47 in last 3 years and its transshipment cargo volume is specified between 80-90 percent in various sources. Besides, the operator company COSCO Shipping plans to develop the port throughput up to 7,2 million TEU in the future. In brief, Piraeus container terminals use the Black Sea and partly East Mediterranean transshipment cargo potential without a serious competitor in the close area.

Development of cargo throughput in Piraeus Port is an important clue of a big opportunity for Turkish container terminals in the Aegean Region. When the Suez Canal (East Port Said terminals) – Valetta route is considered as the main route, the deviation distances from this main route and duration of deviated navigation at slow and normal steaming are given in Table 15. for Piraeus Port, POI and Çandarlı Port project.

Table 15. Deviation Distances and Durations

<i>Port</i>	<i>Deviation (nm)</i>	<i>Difference from Piraeus dev. (nm)</i>	<i>Duration of dev. at 20 nm/h</i>	<i>Duration difference from Piraeus dev. (at 20 nm/h)</i>	<i>Duration of dev. at 24 nm/h</i>	<i>Duration difference from Piraeus dev. (at 24 nm/h)</i>
<i>Piraeus</i>	173	-	8 h 39 min	-	7 h 13 min	-
<i>POI</i>	324	151	16 h 12 min	7 h 33 min	13 h 30 min	6 h 17 min
<i>Candarli</i>	317	144	15 h 51 min	7 h 12 min	13 h 13 min	6 h

In consideration of normal speed navigation, choosing Turkish alternative container terminals as transshipment hub instead of Piraeus Port will cause a need of extra time on a voyage around 6 hours and an extra navigation distance around 150 nm if all the other conditions are same. (Figure 33)

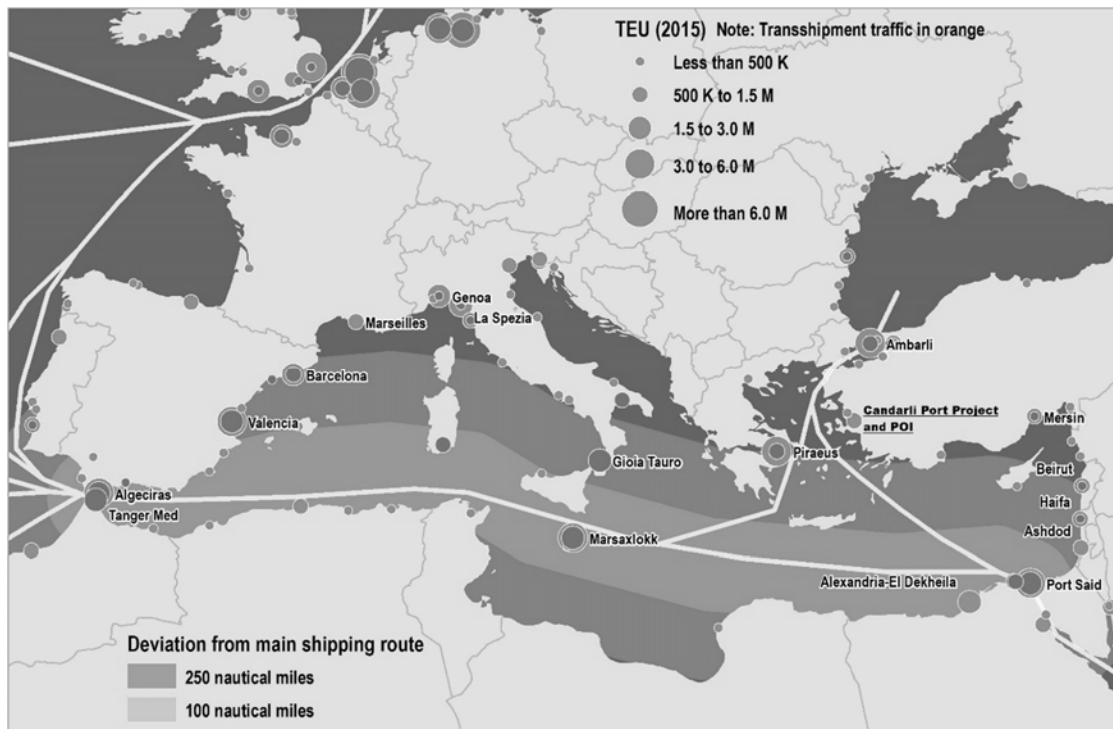


Figure 33. Main container shipping routes

(Transportgeography.org, 2019)

Nowadays, liner shipping companies serve door-to-door instead of port-to-port. Major shipping lines services are not limited just among hub ports. Hence, they also need and have to provide efficient and effective transportation services following the discharge of cargo at the hub port. Besides, nowadays they also serve in feeder routes with their own vessels or with agreed other small scale shipping lines. When the Table 16 examined, (if all the other conditions are same) alternative Turkish Aegean container terminals have a clear time and distance advantage for the shipment of boxes after the transshipment to the final destinations which are located at the Black Sea or at North Aegean Sea.

Table 16. Time and Distance Advantages for Feeding Routes After Transshipment

CONTAINER TERMINALS	Piraeus (nm)	POI (nm)	Distance Advantage of POI (nm)	Time Gain at 24nm/h with POI	Candarli (nm)	Distance Advantage of Candarli (nm)	Time Gain at 24nm/h with Candarli
Tekirdag	293	208	85	3 h 32 min	183	110	4 h 36 min
Bandirma	314	229	85	3 h 32 min	204	110	4 h 36 min
Gemlik	353	268	85	3 h 32 min	243	110	4 h 36 min
Ambarli	339	254	85	3 h 32 min	229	110	4 h 36 min
Burgas	472	387	85	3 h 32 min	362	110	4 h 36 min
Varna	495	410	85	3 h 32 min	385	110	4 h 36 min
Constantza	540	455	85	3 h 32 min	430	110	4 h 36 min
Odessa	692	607	85	3 h 32 min	582	110	4 h 36 min
Novorossiysk	803	718	85	3 h 32 min	693	110	4 h 36 min
Poti	931	846	85	3 h 32 min	821	110	4 h 36 min
Batumi	937	852	85	3 h 32 min	827	110	4 h 36 min
Samsun	717	632	85	3 h 32 min	607	110	4 h 36 min
Thessaloniki	245	244	1	1 min	228	17	10 min
TOTAL	7131 nm	6110 nm	1021 nm	42 h 25 min	5794 nm	1337 nm	55 h 29 min

Even if only one feeder vessel calls these 13 terminals as a regular ring route from one of the Turkish hubs instead of Piraeus Port every round it will navigate a less distance between 86 – 127 nm and it will gain an extra time between 3,5 – 4,5 hours on the voyage.

These time and distance advantages will vary for different feeder route designs but always there will be an advantage over against Piraeus Port. In the comparison of these ports, similar calculations will be valid for feeder services to Eastern Mediterranean ports which are located in south or southeast side of Turkey when the cargo flow is from west to east on the main route. If the large ships, which navigate from west to east on the main route, calls Turkish Aegean ports instead of Piraeus Port they will create time and cost efficiencies for feeder services at East end of Mediterranean destinations.

Within this scope, Piraeus Port is serving in a light competition business environment for the Black Sea and North Aegean. It does not have any hub competitor in the Aegean Sea. Hence, its transshipment cargo is a potential demand for hub port projects in Turkish west shores. Although Master Plan Study of Turkish Coastal Structures (2010) forecasted 2.6 million TEU throughput for Piraeus Port for 2020, it has already reached 4.9 million TEU in 2018. Fast increasing throughput of Piraeus Port is beyond the general trend in the industry and the current situation cannot be kept in the long term. When the Gioia Tauro, Constantza throughput decreases has taken into account it is clear that there is a replacing transshipment cargo among hub ports. Nevertheless, in progress of time, the rapid development of Piraeus throughput will slow down gradually. Hence, if 90% of its throughput is assumed as transshipment box then approximately 4.4 million TEU will be subject to competition at the current situation. As shown in Figure 34 world seaborne container trade growth is slower than the Far East-Europe growth where the last 20 years average growth rates are 6.9% versus 7.7%. Nevertheless, the result in the last 10 years is different. While the world average is 4.1% Far East-Europe route container trade growth is 1.7%. On the other hand combination of both statistics has a 2.9% average growth rate for the last 10 years. If this average rate is used as an annual average growth ratio to forecast future transshipment cargo amount of Piraeus Port the result will be as shown in Figure 35.

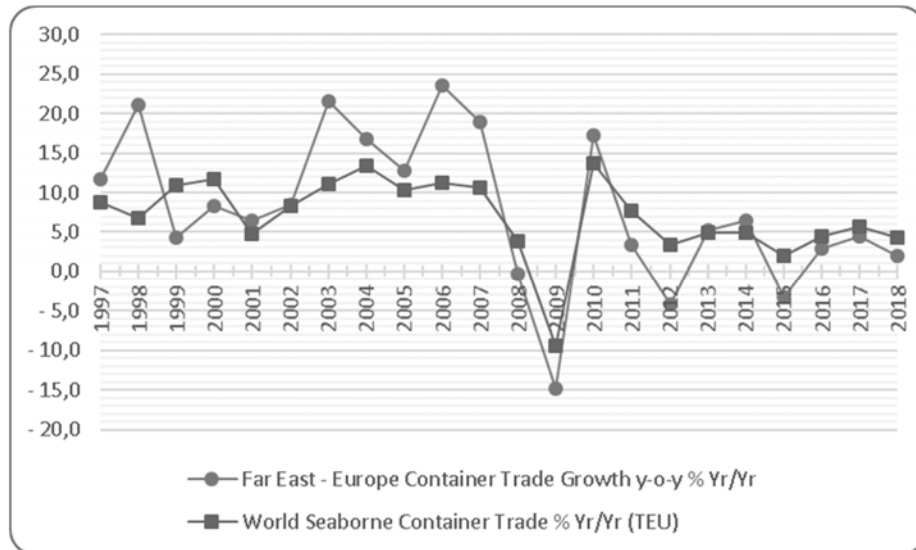


Figure 34. Seaborne Container trade growth rates
(compiled from Clarkson data)

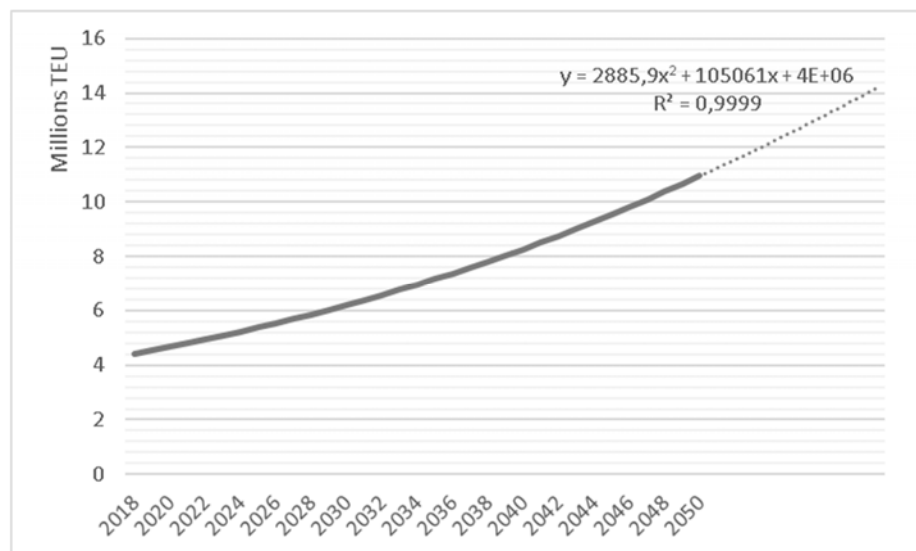


Figure 35. Transshipment cargo forecast

Finally, that principle should not be forgotten. In the short term forecast, the past will repeat in the future or the future will pretend the past. But, in the long term prognosis, this theory is not valid. The future is full of uncertainties. Especially, technological developments and socio-economic issues can present completely different scenarios which are out of the predictions. However, even though the flat market conditions after 2008, the world economy and trade is still growing at slow steam. Therefore, in this depressing situation with a 2.9% increase rate, the Piraeus Port which is not close to a main east-west route like Valetta, Spain and Egypt terminals can expect a transshipment demand around 11 million TEU in 2050. When considered Piraeus Port is operated by the second big alliance (in terms of capacity), Ocean Alliance member COSCO Line; a neutral transshipment hub terminal in the region can utilize from the competitor alliances' cargoes. Briefly, it can be assumed a total of 225 million TEU transshipment cargo will be open to competition in a recessed market until 2050.

4.2.4. Cost-Benefit Analysis (CBA) with Monte Carlo Simulation

In this part of the study, POI rehabilitation and Çandarlı Port projects will be presented as two substitute investments and they will be evaluated according to their future returns in terms of business perspective, thus their profitability. The future is comprised of uncertainties. Hence, it needs to assumptions to specify the calculation bases. Nevertheless, indicating certain points can mislead the analysis if the future is different from that point. Therefore, the assumptions will be the intervals between minimums and maximums. Afterwards, the combination of randomly selected scenarios will be simulated 100 thousand times in Monte Carlo Simulation as a probabilistic method to find out as many different probabilities of NPV, IRR, total CFs and payback periods (PP).

4.2.4.1. Assumptions

Item by item assumptions used in the study as follows:

- Initial Investment Costs: As mentioned before there are no officially published cost details about projects and the values in several sources are away from reflecting the reality when they benchmarked with literature. Hence, for POI rehabilitation project the minimum value of 270 million USD in environment impact report and the maximum value of 650 million USD in Aegean Development Agency report are specified. And for Çandarlı Port project the most mentioned amount by relevant parties at the beginning was 650 million USD. Then the breakwater was completed by spending 455 million TRY which equals to approximately 125 million USD in 2017 (1 USD = 3,64 TRY). Besides, in some sources, 910 million € which equals to approximately 1 billion USD is specified as the total cost. Hence, by subtracting the breakwater cost the 525 – 875 million USD interval is specified for Çandarlı Port.
- Operating Costs: These amounts will include all the administrative, labour, material and other various costs to operate the ports except depreciation. For POI, 2018's total expense of 28 453 511 USD is benchmarked as the minimum; and because of 75% of planned 2.5 million TEU capacity which equals to 1.875 million TEU, that is approximately three times higher current throughput, the minimum value is tripled and 85 360 533 is indicated as maximum. Nevertheless, the key cost for container terminals is in the workforce. In POI 70% of all expenses are for labour and 536 staff is employed at the port. Although POI is a public port Çandarlı will be a BOT project. Beyond no doubt, the number of workers will be less and the efficiency will be higher at Çandarlı Port. However, to prevent creating a cost advantage for Çandarlı Port the operating costs will be taken into account at the same level. Besides, operating costs are formulated coherent with the handling

rates. Thus, operating costs have a linear ratio with the number of TEU handled at the port between the specified min-max limits.

- Revenues: Nowadays, there are value-added services at container terminals and revenue items of ports are differentiated. These services are also marketing instruments for ports and create opportunities for extra profit. However, they are sophisticated and the utilization ratio of them is unpredictable. Hence, two revenue items are chosen as domestic and transit box handling. They are specified at low level all-inclusive average rates for every TEU handled at a port. Especially, Çandarlı Port project with 4 million TEU initial capacity is a candidate to be a transshipment node at the region. Hence, low indicated average rates aimed to attract cargo from Piraeus Port. Although the international standards for a 20 feet box transshipment is around 60 USD (Yetkili et al., 2016) the minimum rate is indicated 40 USD for competitive advantage. Nevertheless, because of the location advantage which was explained in the previous subheading, the demand may be higher in future transshipment. In this scope, the maximum amount is indicated 80 USD for transit cargoes. And for domestic cargo, an average interval of 60-120 USD assumed for every TEU. Besides, the analysis is formulated as not to let exceeding the port handling capacity while calculating the revenues. POI is allowed to handle 2.5 million TEU and Çandarlı can handle 4 million TEU as maximum.
- Depreciation, Tax and Discount Rate: Infrastructure and superstructure have different life cycles and depreciation rates. While a concrete pier is annually depreciated %5, a truck is 20% - 25%. On the other hand, every equipment which ended its lifecycle will be renewed and depreciation will restart for this item. When considered the 25 years of analysis 4% is indicated a general average depreciation rate. The corporate tax is %22 and the discount rate is specified as 5%. Tax will be implied after depreciation deducted from revenues and depreciation will not be included in CFs.

- Demand: The assumption is based on previous demand forecasts. The annual worst and best levels for domestic demand forecast are indicated as minimums and maximums. Then, POI's current share in the region's total throughput of 40% was considered as the beginning point for the new investment share in domestic demand. Afterwards, the share is increased 1% every year; same for both projects. For transshipment demand, the main competitor in the region Piraeus Port cargo forecast is used. The trendline is proportioned beginning with 1% of Piraeus forecasted cargo and the share is increased 1% every year for the worse scenario, and 2% is for the best case. At this point, POI has begun with a 10% transshipment share in Aegean regional competition because of its mainly hinterland focused services and limited capacity in comparison with Çandarlı Port. However, Çandarlı Port has begun with 40% share because of its higher capacity which is targeted transshipment market segment and to prevent this capacity being mathematically idle in the future while there is a demand for handling.

4.2.4.2. Findings

Two Monte Carlo Simulations were run with assumed randomly chosen variables between the minimum and maximum intervals to calculate 100 thousand different possibilities of NPV, IRR, PP and total CFs. Descriptive statistics of the above mentioned financial instruments are shown in Table 17.

Table 17. Descriptive Statistics

		<i>Mean</i>	<i>Median</i>	<i>Standard deviation</i>	<i>Skewness</i>	<i>Kurtosis</i>
POI	NPV	372 178 101,63	372 392 074,98	111 092 559,93	0,00	2,32
	IRR	10,75%	0,10	0,03	0,53	2,45
	PP	11,67199698	11,69063371	1,9927459	-0,053273421	2,438649575
	Total CFs	1 226 875 094,40	1 226 302 698,00	134284181,5	0,027068358	2,801835386
ÇANDARLI	NPV	384 852 405,00	385 125 044,89	112 376 761,09	0,01	2,50
	IRR	8,40%	0,08	0,01	0,27	2,35
	PP	14,47629880	14,44177152	1,467508246	0,010630695	2,694755285
	Total CFs	1 687 651 010,36	1 686 855 438,00	163388659,7	0,045511308	2,909764914

Although the Çandarlı project's overwhelming supremacy in average CFs with a 460.7 million USD extra cash on POI's total CFs, when the mean of NPVs are compared there is a 12.6 million USD difference between the investments in favour of Çandarlı Port which means Çandarlı project generated higher cash but its initial cost was also higher than POI's. Nevertheless, POI's NPV probabilities are distributed symmetrically and they have a zero skewness while the Çandarlı's score is 0.01 that demonstrated a little skew. In addition to this, Çandarlı has a wider distribution than POI with a higher standard deviation. Kurtosis stats shows that POI's NPV distribution is flatter as shown in Figure 36 and 37. although the Çandarlı's was more peaked. At any rate, both the projects have generated positive NPVs at every run of 100 thousand simulations and they do not have any losing scenario. It should be taken into account that the assumptions have indicated only one discount rate. If the real discount rate will have a lower average than the assumed %5, it will be in favour of the big scaled project. Because the future CFs can compensate for the initial investment with their higher valuation. When the discount rate is zero, then the NPV will be equal to the difference between total CFs and initial investment.

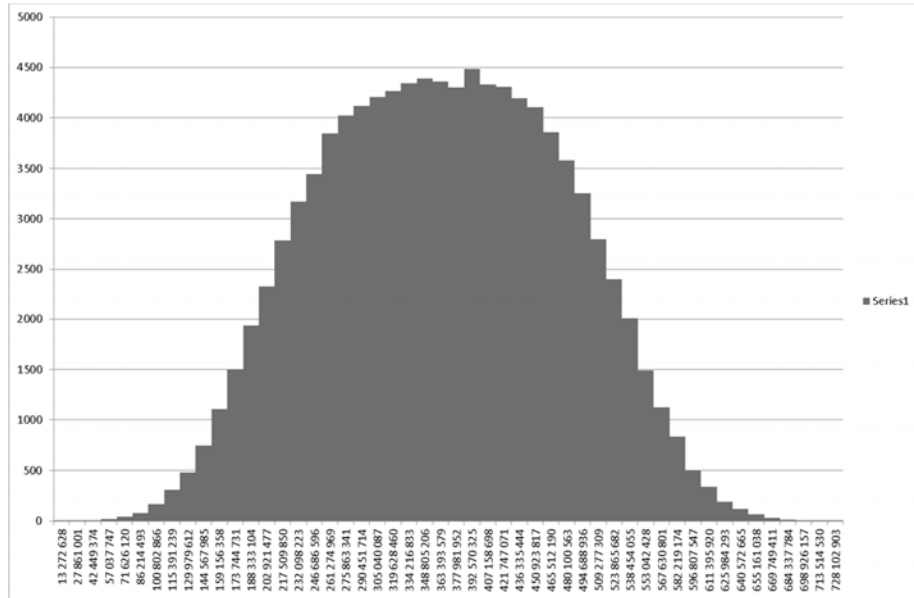


Figure 36. POI project simulation NPV distribution

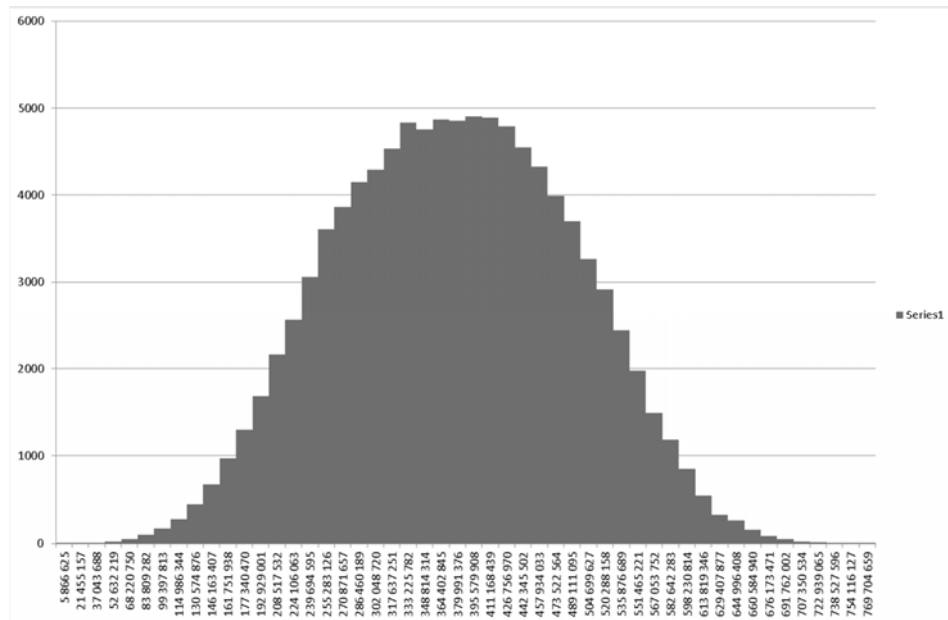


Figure 37. Çandarlı project simulation NPV distribution

On the other hand, POI's return is higher when it is proportioned with the initial investment. Hence, it has a 10.75% IRR while Çandarlı Project's is 8.40%. When their distributions are compared in Figure 38 and 39, this time POI has a peak one while Çandarlı's is flatter. However, both of their Kurtosis values are under 3.0. Hence they are normally distributed. Both projects have unsymmetrical IRR distribution but POI's distribution skewed more to the left. Nevertheless, it is repeating the higher values more than Çandarlı. Besides, while Çandarlı can reach maximum IRRs around 12%, POI can reach more than 18%. It should not be forgotten IRR method does not show the wealth generated by the investment. A higher IRR is not a demonstration of higher profit. IRR just gives an idea about the compensation ratio of the initial investment. Hence, it is considered in investment appraisals but the main decision point is the NPV in general.

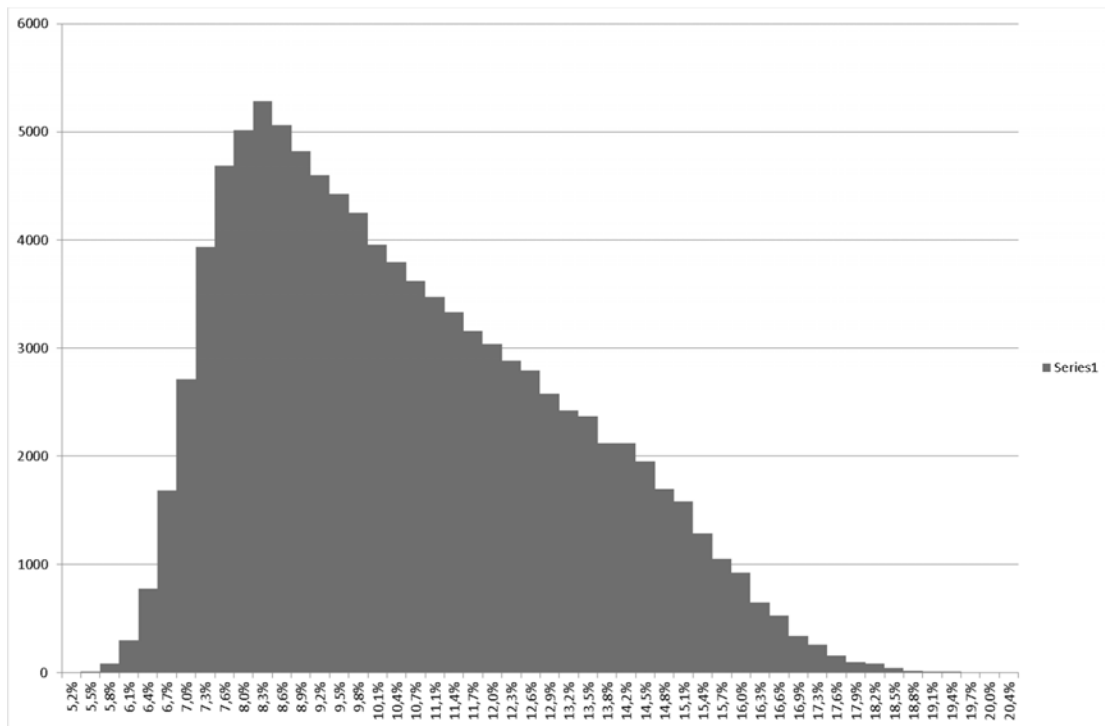


Figure 38. POI project simulation IRR distribution

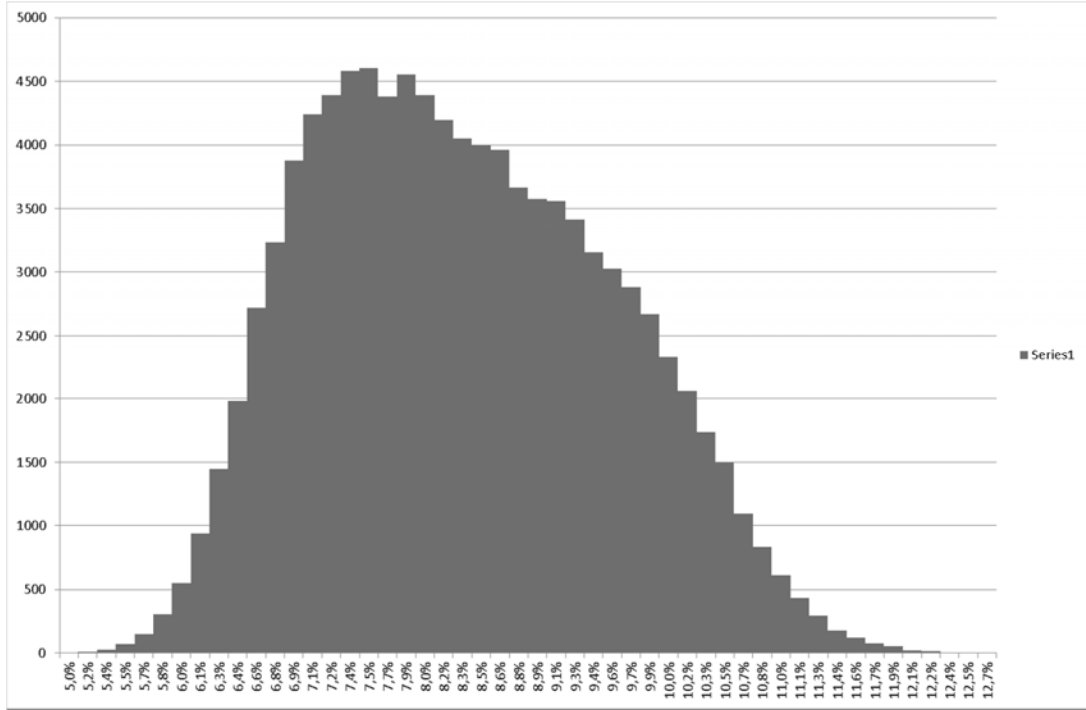


Figure 39. Çandarlı Project Simulation IRR Distribution

When the PPs are compared POI is paying the initial investment averagely 3 years before Çandarlı Project and both project's PPs are normally distributed in terms of Kurtosis. In consideration of the lower initial investment, it was an already expected result at the beginning of analysis. However, Çandarlı Port Project creates quite good CFs than POI and both of them are distributed normally. But CFs and PPs are not good methods to evaluate the investments solely. They give an idea about the future of projects and they help for decision making about financing issues like loan payments, interests, and maturities.

CHAPTER FIVE – CONCLUSION AND RECOMMENDATIONS

This chapter will begin with a critical evaluation of the study and then the conclusion of analysis will be commented. Recommendations will finalize the section.

5.1. Limitations and Criticism of Study

First of all, unavailability of data, prevented practising an allocative (price) efficiency analysis, ship turnaround time, berth and land utilization comparisons of POI and its competitors. The competitors of POI even did not accept sharing their annual throughput for analysis. Hence, the efficiency analysis is based on mainly public data which are obtained from secondary resources. Nevertheless, the DEA method cannot take into account the restrictive effects of some external conditions like approach channel depth. Inadequate deepness in a port basin and approach channel may prevent a port from using its technical capacity. Moreover, workforce input could not be used in DEA. When considered labour is the largest expenditure item in container terminals, efficiency comparison of the workforce is important to understand the port's efficiency level.

On the other hand, CBA was based on investment appraisal of two alternative projects in terms of business profitability. Either private or public ports have many indirect impacts on socio-economic or environmental aspects. However, it is quite hard identification of these costs and benefits or expression of them in money. Nonetheless, a benchmarking study could not be obtained during the literature view to use in the assumptions. On the

other hand, the lack of officially published data about the investment cost of projects is another issue that affects the result of simulations.

In the demand forecast, the regression analysis could have more observations but it is impossible to find weekly or daily data for socio-economic indicators like volume trades, GDP or population. Besides, an inadequate observation number could cause GDP and population variables to be insignificant.

Use of Monte Carlo Simulation method is an important advantage for the study. It is impossible to calculate thousands of capital budgeting NPV, IRR, and PP techniques manually at wide intervals. The simulation provides a combination probabilities of different detailed scenarios.

5.2. Conclusion

DEA results demonstrate POI's comparative efficiency. It is still efficient than its close competitors. However, they are following the POI at a close range. While POI's efficiency score is 0.733, two of its main competitors following it with 0.689 and 0.677 in 6th and 7th rank. POI is at the 5th rank among 18 container terminals. Nevertheless, 5 terminals are placing at first rank with 1 point efficiency scores. In fact, POI is placing at 10th place among 18 and it needs extra 233 thousand TEU output to have 1 point efficiency score. Additionally, the current ranking of competitors is mainly related to their unutilized capacities. They have a low output which is caused by low demand. Therefore, the increase in demand will change the result in favour of them.

On the other hand, competitors of POI do not have draught problems and they are ready for berthing larger vessels. POI project will dredge the approach channel and port basin down to -14 m at first phase which is a short-term plan and it will be even lower than the competitors' current -16.8 m average berth depth. Extra dredging will cause extra cost in the future. Besides, the current infrastructure is planned for a maximum -17 m depth.

When last 10 years' throughput in Aegean container terminals of Turkey is examined, it is obvious there is a cargo shifting from POI to three Aliaga terminals. Hence, POI's share is decreasing year to year while the competitors' are rising. But, very low transshipment rates demonstrate that this competition is for the hinterland cargo. Therefore, none of these four ports are competing for acquiring transit cargo from Piraeus Port traffic. Nevertheless, Piraeus Port is continuously investing in infrastructure and superstructure to develop its throughput and it does not seem to possible current fragmental and uncooperative structure of Turkish terminals can compete with it for transit boxes.

Concerning with the transshipment cargo competition, while Çandarlı Port project has the expansion opportunity up to 12 million TEU, POI project will be stuck at 2.5 million TEU in future because of the absence of expansion area in the middle of the city. Hence, POI will not have competitiveness capacity or potential against Piraeus when considered it is 4.9 million TEU throughput with around 90% transit cargo.

From the profitability angle, CBA shows that Çandarlı Port has higher returns in comparison with POI because of the higher mean of NPVs even though the difference between projects is not very high. However, the uncertainty for the initial cost of two projects causes to misleading conclusions in analysis because of specified wide intervals for them. NPV is sensitive to initial investment which is not subject to the discount rate while the future CFs are.

On the other hand, POI is located in a gulf which has fed by 33 streams and it has sediment input matter for centuries. Hence, the POI dredging project will not solve the depth problem in the long term. Periodical dredging will be required for port basin and approach channel in the future and it will create an extra cost. This cost has not been taken into account at environmental impact assessment and any report or press release. Apart from the cost, the projected and future required dredging material discharge will be concern topics for the POI investment.

Another point is the progressing constructions of highway and railway connections to Çandarlı Port project location. While this study is conducted highway construction was close to completion. (Figure 40) This highway will cost 427 million € bidding value. (UAB, 2018) Besides, 965 million TRY valued Aliğa-Çandarlı-Bergama railway construction was bid in 2015 and it is planned to be finished in 2021. Although these infrastructures will not serve only to the port, it can be said Çandarlı Port Project's road and railway connections with the hinterland are almost ready.



Figure 40. Highway construction to Çandarlı Port

5.3. Recommendations

First of all, an institutional research based on a full set of data from private entities by the government is advised for investigating the current situation of efficiency, profitability, demand and supply issues for planning the future outline of investments. Besides, certain cost calculations should be made for both POI and Çandarlı projects. Then, the initial investment costs will be clearer for undertaking a CBA. It is not feasible and environmentally acceptable to invest both projects while current supply is so much more over than the current demand. Hence, data gathering is important at this point for understanding the analysis for the future.

Secondly, the competition among 4 Turkish container terminals on the west shore should evolve to a cooperative competition which is called co-opetition in literature. Currently, there is a tough competition among 4 container terminals. POI began to pursue a different price policy to attract the customers who owned a big volume of cargoes by providing discounts after certain numbers are exceeded. There are problems among other private terminals about the use of connection roads and expansion projects. When considered a total of 3.8 million TEU theoretical capacity of 3 private and 1 public terminal, it is high for the domestic cargo but also inefficient for transshipment competition in the region. Hence, 4 terminals should be managed under collaboration and cooperation for marketing strategies and work division.

Thirdly, the future need beyond the planned depths (which are specified between -14 m and -17 m) and expansion requirements for the POI project should be taken into consideration by the decision-makers. In container terminal market the trends can change rapidly. A well-doing terminal can easily be pulled down by its incapability to reply and adapt to the new trends in the market.

In conclusion to recommendations, smart port technologies are the future of container terminals. Because the labour is the highest cost item for terminals and reduction in cost will increase the profitability and create an opportunity to decrease the tariffs for having

a competitive advantage. In this respect, a smart technology equipped and high capacitated container terminal will have a competitive advantage in terms of cost and scale. Besides, this terminal will not have current depth and future expansion problems. It will be away from the residential areas of city and traffic congestion. On the other hand, similar to the Malmö example, property value of city centre located, old and costly port can be used to finance new one by evaluating the land as residential and recreational area.

REFERENCES

- Arı, K. (2011). İzmir’de Deniz Ulaşımı ve Ticaretinin Kent Kimliğinin Oluşumu Üzerindeki Etkileri [Effects of Maritime Transportation and Trade on Development of City Identity in İzmir]. Dokuz Eylül University Maritime Faculty Journal, Special Issue, pp. 1-105. Retrieved from <https://dergipark.org.tr/en/pub/deudfd/issue/4584/62754>
- Arisoy Y. (2017). Port Planning, Coastal Structures and Ports Clash Handouts [pdf file]. Retrieved from <http://kisi.deu.edu.tr//yalcin.arisoy/>
- Ashe-Edmunds, Sam. (2019). Productivity Versus Efficiency. Retrieved from <http://smallbusiness.chron.com/productivity-versus-efficiency-66229.html>
- Ateş, A., & Esmer, S. (2014). Farklı Yöntemler ile Türk Konteyner Limanlarının Verimliliği [Calculation of Container Ports Efficiency in Turkey with Different Methods]. Journal of Efficiency, (1), pp. 61-76. Retrieved from <https://dergipark.org.tr/download/article-file/203035>
- Banker, R. D., Charnes, A. & Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. Management Science, 30(2), pp. 1078–1092. DOI:10.1287/mnsc.30.9.1078
- Baran H. (2006). İzmir Alsancak Limanı ve Özelleştirme Süreci [İzmir Alsancak Port and Privatization Process]. Retrieved from http://www.izto.org.tr/Portals/0/izmir_alsancak_limani_ve_ozellestirme_sureci.pdf

- Baran, H. (2008). TCDD İzmir Alsancak Liman İşletme Müdürlüğü 2006-2007 Verilerine Dayanılarak Yapılan Analiz Çalışması [The Analysis Depending on 2006-2007 Data of Directorship of İzmir Alsancak Port] Retrieved from <http://www.izto.org.tr>
- Barros, C. P. & Athanassiou, M. (2004). Efficiency in European Seaports with DEA: Evidence from Greece and Portugal. *Maritime Economics and Logistics*, 6, pp. 122-140 DOI: 10.1057/97811374757
- Bartan, D. (2007). Konteyner Terminallerinde Performans Değerlendirmesi ve İzmir Alsancak Limanı Örneği [Performance Evaluation at Container Terminals and İzmir Alsancak Case] (master's thesis). Yıldız Technical University, İstanbul, Turkey. Retrieved from <https://docplayer.biz.tr/52866804-Konteyner-terminallerinde-performans-degerlendirmesi-ve-izmir-alsancak-limani-ornegi>
- Baysal, M. E., Uygur, M., & Toklu, B. (2004). Veri Zarflama Analizi ile TCDD Limanlarında Bir Etkinlik Ölçümü Çalışması [An Efficiency Measurement Study with Data Envelopment Analysis at TCDD Ports.] *Gazi University Engineering-Architecture Faculty Journal*, 19(4). Retrieved from <https://dergipark.org.tr/en/pub/gazimmfd/issue/6662/88975>
- Brooks, M. R. (2000). *Sea Change in Liner Shipping: Regulation and Managerial Decision-making in a Global Industry* (Vol. 1st ed). Amsterdam: Pergamon Press. Retrieved from <http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=nlebk&AN=91216&site=eds-live&scope=site>

- Büyüközer, A. A. (2006). Konteyner Terminali Planlaması ve Kapasite Analizi [Planning Container Terminal and Analysis of Capacity] (doctoral dissertation). İstanbul Technical University, Turkey. Retrieved from <https://polen.itu.edu.tr/handle/11527/8725>
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, 2, pp. 429–444. DOI: 10.1016/0377-2217(78)90138-8
- Clarkson Research. (2019). Shipping Intelligence Network. Time series. Retrieved from <https://sin.clarksons.net/Timeseries>
- Cooper, W. W., Seiford, L. M. & Tone, K. (2007). The Basic CCR Model. *Data Envelopment Analysis: a Comprehensive Text with Models, Applications, References and DEA-Solver Software*, pp. 21-39. DOI: 10.1007/978-0-387-45283-8
- Coto-Millán, P., Núñez-Sánchez, R., Pesquera, M. A., Inglada, V., & Castanedo, J. (2010). A Cost–Benefit Analysis of a New Container Terminal. In *Essays on Port Economics*, pp. 307-321, Physica, Heidelberg.
- Cullinane, K., Song, D. W., Ji, P., & Wang, T. F. (2004). An Application of DEA Windows Analysis to Container Port Production Efficiency. *Review of Network Economics*, 3(2). DOI: 10.2202/1446-9022.1050

- Cullinane, K., Ji, P., & Wang, T. F. (2005). The Relationship Between Privatization and DEA Estimates of Efficiency in the Container Port Industry. *Journal of Economics and Business*, 57(5), pp. 433-462. DOI: 10.1016/j.jeconbus.2005.02.007
- De Monie, G. (1987). UNCTAD Monographs on Port Management. Monograph No.6 Measuring and Evaluating Port Performance and Productivity. Retrieved from <https://unctad.org/en/pages/publications/Port-Management-Monograph.aspx>
- Ding, Z. Y., Jo, G. S., Wang, Y., & Yeo, G. T. (2015). The Relative Efficiency of Container Terminals in Small and Medium-Sized Ports in China. *The Asian Journal of Shipping and Logistics*, 31(2), pp. 231-251. DOI: 10.1016/j.ajsl.2015.06.004
- DOKAY Ltd. (2016). Rehabilitation Project of Izmir Bay and Port Environmental Impact Assessment Report. Ankara, Turkey. Retrieved from <https://webdosya.csb.gov.tr/db/izmir/editordosya/TCDD.pdf>
- Farrell, M. (1957), The Measurement of Productive Efficiency, *Journal of the Royal Statistical Society*, 120(3), pp. 253-290. DOI: 10.2307/2343100
- Ferrari, C., Bottasso, A., Conti, M. & Tei, A. (2018). *Economic Role of Transport Infrastructure: Theory and Models*. Amsterdam, Netherlands. Elsevier.
- Frangakis E. (1985). The Ottoman Port of İzmir in the Eighteenth and Early Nineteenth Centuries, 1695-1820. *Revue de l'Occident Musulman et de la Méditerranée*, 39, pp. 149-162. DOI :10.3406/remmm.1985.2071

- González, M., & Trujillo, L. (2009). Efficiency Measurement in the Port Industry: A Survey of the Empirical Evidence. *Journal of Transport Economics and Policy*, 43(2), pp. 157-192. Retrieved from <http://www.jstor.org/stable/20466776>
- Güler, N. (2002). Economic Evaluation of Port Investments. *Pomorski zbornik*, 40(1), pp. 205-221. Retrieved from https://www.researchgate.net/publication/44785510_ECONOMIC_EVALUATION_OF_PORT_INVESTMENTS
- Güner, S. & Coşkun, E. (2014). Efficiency Measurement of Passenger Ports with Data Envelopment Analysis and Utilizing Malmquist Productivity Index. *Data Envelopment Analysis and Performance Measurement*, 147. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.664.8733&rep=rep1&type=pdf#page=163>
- Güner, S. (2015). Proposal of a Two-Stage Model for Measuring The Port Efficiency and an Implication on Turkish Ports. *Alphanumeric Journal*, 3(2), pp. 99-106. DOI: 10.17093/aj.2015.3.2.5000142149
- International Money Fund (IMF). (2019). IMF Data Access to Macroeconomic and Financial Data. Retrieved from <http://data.imf.org/?sk=388DFA60-1D26-4ADE-B505-A05A558D9A42>
- ITF (2015), Port Investment and Container Shipping Markets, ITF Round Tables, No. 157, OECD Publishing, Paris, France. DOI: 10.1787/9789282107850-en
- İzmir Chamber of Commerce (İZTO). (n.d.). Cruise Tourism in Izmir. Retrieved from <http://www.izto.org.tr/tr/izmirde-kruvaziyer-turizmi>

- İzmir Water and Sewerage Administration (İZSU). (2019). Körfez Hayat Buluyor [Gulf Comes to Life] Retrieved from <https://www.izsu.gov.tr/tr/TesisDetay/1/27/2?AspxAutoDetectCookieSupport=1>
- İzmir Chamber of Commerce (İZTO). (2004). Kent Raporları [City Reports]. Retrieved from <http://www.izto.org.tr/tr/kentsel-raporlar>
- İzmir Chamber of Commerce (İZTO). (2006). Research and Development Bulletin. June, 2006. Retrieved from <http://www.izto.org.tr>
- İzmir Development Agency (İZKA) (n.d.) İzmir Denizyolu Lojistiği: Limanlar [İzmir Seaway Logistics: The Ports] Retrieved from http://www.investinizmir.com/upload/Node/27441/files/IZMIR_DENIZYOLU_LOJISTIGI_LIMANLAR.pdf
- Kaboğlu O., S., Kaboğlu, G., Taylan Akdag, C., Kisacık, D., Uzkuç, G.,K., & Besiktepe, S. (2016). İzmir İç Körfezi'nin Güncel Sedimentolojik Özellikleri (Actual Sedimentological Properties of the Inner Izmir Bay) Retrieved from https://www.researchgate.net/publication/304570248_IZMIR_IC_KORFEZI'NI_N_GUNCEL_SEDIMENTOLOJIK_OZELLIKLERI_ACTUAL_SEDIMENTOLOGICAL_PROPERTIES_OF_THE_INNER_IZMIR_BAY
- Köktaş, M. (2007). Application of Information Technologies in Port Logistics Management: Port of İzmir Case. [master's thesis] Dokuz Eylül University Institute of Science. İzmir, Turkey.

- Kutin, N., Nguyen, T. T., & Vallée, T. (2017). Relative Efficiencies of ASEAN Container Ports Based on Data Envelopment Analysis. *The Asian Journal of Shipping and Logistics*, 33(2), pp. 67-77. DOI: 10.1016/j.ajsl.2017.06.004
- Lloyds List. (2019). One Hundred Ports 2019. Retrieved from <https://lloydslist.maritimeintelligence.informa.com/one-hundred-container-ports-2019>
- López-Bermúdez, B., Freire-Seoane, M. J., & González-Laxe, F. (2019). Efficiency and Productivity of Container Terminals in Brazilian Ports (2008–2017). *Utilities Policy*, 56, pp. 82-91. DOI: 10.1016/j.jup.2018.11.006
- Ma, S. (2018). *Maritime Economics*. World Maritime University Textbook. World Maritime University. Malmö, Sweden.
- Mediterranean Shipping Company (MSC). (2019). Our Fleet. Retrieved from <https://www.msc.com/mda/about-us/our-fleet#>
- Mokhtar, K. (2013). Technical Efficiency of Container Terminal Operations: A DEA Approach. *Journal of Operations and Supply Chain Management (JOSCM)*, 6(2), pp. 1-19. Retrieved from <https://ageconsearch.umn.edu/record/289396/files/14064.pdf>
- Musso, E., Ferrari, C., & Benacchio, M. (2006). Port Investment: Profitability, Economic Impact and Financing. *Research in Transportation Economics*, 16, pp. 171-218. DOI: 10.1016/S0739-8859(06)16008-4

- Oral E.Z., Özerden A. (2010). Improvement of Vessel Services and Handling Facilities in İzmir Alsancak Port. İzmir Chamber of Commerce. Retrieved from <http://www.izto.org.tr/tr/izmir-alsancak-limaninda-yuk-ve-gemi-olanaklarinin>
- Özkırlı, B. & Ürker, O. (2012). İzmir Körfezi ve Limanı Rehabilitasyon Projesi Kapsamında, Gediz Deltası Sulak Alanı İçerisinde Yapılması Planlanan Tarama Malzemesi Depolanması ve İşlenmesi Sürecinin Ekolojik ve Hukuki Olarak İncelenmesi [Legally and Ecologically Examination of Dredging Material Discharge and Process in Gediz River Delta Area in the Scope of İzmir Bay and Port Rehabilitation Project]. İzmir Nature Association Press. İzmir, Turkey. Retrieved from https://www.dogadernegi.org/wp-content/uploads/2015/08/DD_Gediz_camur_tehdit_raporu_121228.pdf
- Palmer, S. (1999). Current Port Trends in an Historical Perspective. Journal for Maritime Research. 1(1), pp. 99-111. DOI: 10.1080/21533369.1999.9668302
- Parliament of Victoria. (2008). Port Phillip Bay: Channel Deepening. Final Report. Retrieved from <https://www.parliament.vic.gov.au/archive/council/SCFPA/PtPhillip/>
- Petry, G. H., & Sprow, J. (1993). The Theory and Practice of Finance in the 1990s. The Quarterly Review of Economics and Finance, 33(4), pp. 359-381. DOI: 10.1016/1062-9769(93)90004-4
- Port of Barcelona. (2019). Statistical Report 2018. Retrieved from <http://www.portdebarcelona.cat/en/web/autoritat-portuaria/estadisticas>

- Republic of Turkey Ministry of Transport and Infrastructure. (UAB) (2019). Directorate General of Merchant Marine, Statistics. Retrieved from http://www.ubak.gov.tr/BLSM_WIYS/DTGM/en/eng_html/20121225_095328_64032_2_64480.html
- Roll, Y., & Hayuth, Y. E. H. U. D. A. (1993). Port Performance Comparison Applying Data Envelopment Analysis (DEA). *Maritime Policy and Management*, 20(2), pp. 153-161. DOI: 10.1080/030888393000000025
- Sahoo, S. (2019). Capital Budgeting & Investment Appraisal Handouts. World Maritime University. Malmö, Sweden.
- Sarkis, J. (2007). Preparing Your Data for DEA. *Modelling Data Irregularities and Structural Complexities in Data Envelopment Analysis*. pp. 305-320 Springer, Boston, USA.
- Socar Terminal. (2019). Institutional Socar Aliğa Terminal. Retrieved from <http://www.petlim.com.tr/kurumsal/socar-terminal>
- Song, D. W. (1999). Productive Efficiency and Privatisation: An Evaluation of Korean Ports Policy (doctorate thesis). University of Plymouth. Retrieved from <http://hdl.handle.net/10026.1/446>
- Sülkü, S. N. (2011). Performansa Dayalı Ek Ödeme Sisteminin Kamu Hastanelerinin Verimliliği Üzerine Etkileri [The Effects of Performance Based Supplementary Payment System on the Efficiency of Public Hospitals]. *Journal of Finance*. 160, pp. 242-268. Retrieved from <https://maliyederigisi.sgb.gov.tr/yayinlar/md/160/012.pdf>

- The Geography of Transport Systems. (2019). Deviation from the Main Shipping Route of Mediterranean Container Ports. Retrieved from https://transportgeography.org/?page_id=2127
- The Institute for Trade and Transportation Studies [ITTS]. (2000). Port Conceptual Development Cost Estimate. Retrieved from <https://www.ittsresearch.org/LATTS1-reports.html>
- Time Turk. (2017). The traffic stopped in İzmir. Retrieved from <https://m.timeturk.com/izmir-de-trafik-durdu/haber-694970>
- Tongzon, J. (2001). Efficiency Measurement of Selected Australian and Other International Ports Using Data Envelopment Analysis. *Transportation Research Part A: Policy and Practice*, 35(2), pp. 107-122. DOI: 10.1016/S0965-8564(99)00049-X
- Torlak C. (2015). Yüzülebilir Körfez Hedefi Hayal Olur. Retrieved from <https://www.sabah.com.tr/egeli/2015/10/26/yuzulebilir-korfez-hedefi-hayal-olur>
- Turkish Statistical Institute (TurkStat) (2019). Annual City Populations [Excel table] Retrieved from http://tuik.gov.tr/PreIstatistikTablo.do?istab_id=1590
- Turkey Wealth Fund (n.d.). Port of İzmir. Retrieved from <http://turkiyevarlilikfonu.com.tr/TR/icerik/68/tcdd-izmir-limani>
- Turkish State Railway (TCDD) (n.d.). Port of İzmir. Retrieved from <http://www.tcdd.gov.tr/content/46>

- Turkish State Railway (TCDD) (2019). Annual Reports. Retrieved from <http://www.tcdd.gov.tr/content/36>
- Turkish State Railway (TCDD) (2019). Statistics. Retrieved from <http://www.tcdd.gov.tr/content/35>
- United Nations Conference on Trade and Development (UNCTAD) (2018). Review of Maritime Transport 2018 Retrieved from <https://unctad.org/en/Pages/publications.aspx>
- US Army Corps of Engineers (USACE). (2017). Dredging Cost Analysis. Actual Amounts for Year 2017. Digital Library. Retrieved from <https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/2659>
- Ustaoglu, E., & Williams, B. (2019). Cost-Benefit Evaluation Tools on the Impacts of Transport Infrastructure Projects on Urban Form and Development. Smart Urban Development. IntechOpen. DOI:10.5772/intechopen.86447
- World Shipping Council (WSC). (2018). Container Ship Design. 50 years of Container Ship Growth. Retrieved from <http://www.worldshipping.org/about-the-industry/liner-ships/container-ship-design>
- World Shipping Council (WSC). (2019). About the Industry: Ports. Retrieved from <http://www.worldshipping.org/about-the-industry/global-trade/ports>
- YARIN. (2016). It is not Late for Anything at Port of İzmir. Aegean Young Business Association Media Outlet. 50. İzmir, Turkey.

- Yetkili, E., Doğan, E., Baltaoğlu, S., & Salihoğlu, İ. (2016). Economic Analysis of Container Transshipment in the Eastern Mediterranean Region. *International Journal of Environment and Geoinformatics*, 3(1), pp. 12-21. DOI: 10.30897/ijegeo.304418
- ZAL Port. (n.d.) About the ZAL Port. Retrieved from <http://www.zalport.com/en-us/who-we-are/about-the-zal-port.html>
- Zheng, X. B., & Park, N. K. (2016). A Study on the Efficiency of Container Terminals in Korea and China. *The Asian Journal of Shipping and Logistics*, 32(4), pp. 213-220. DOI: 10.1016/j.ajsl.2016.12.004